KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: DECEMBER 2, 1889.

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ROCK-PINNACLES.

By Prof. G. S. BOULGER, F.L.S., F.G.S., &c.

FEW considerations are more conducive to a due sense of human littleness and of the grandeur of Nature than a study of the manifold ways in which physical causes will sometimes bring about the same result. Towering over an English heath or moor, or overhanging the sides of a romantic river-worn ravine, rising among Swiss pine-clad slopes, withstanding the fury of Atlantic waves off the coasts of Orkney or Cornwall, or standing up out of the arid plains of Colorado, we see pinnacles of stone, forming an integral part of the neighbouring rocks, but hewn in divers ways by Nature's hands. Often grotesque in outline, suggesting a squatting toad, a huge heathen idol, a Christian pulpit, or the human form, they present to our imagination—

> Shapes,
> The sport of nature, aided by blind chance,
> Rudely to mock the toiling works of man.

This "blind chance" is, however, as in so many other supposed cases of its operation, susceptible of scientific examination. Varied as have been the forces at work, and still more varied as their combined results may appear, they will yet reveal their secret to the geologist, obedient to the charm which he received from his master-magician Lyell: "causes now in action are the same as those in operation in the past." We propose to describe some typical examples of these rock-pinnacles, and to attempt the elucidation of their origin. First, however, we must explain that by a "rock-pinnacle" we understand a mass of rock, more or less tower-like, detached above, but united below to other rock of the same nature. By this definition the consideration of wholly detached, or stranded, masses is for the present put aside.

Where our coast-line is made up of soft or loose material, as is mainly the case from Tees to Thames, we have wide-sweeping bays, such as Bridlington, low cliffs such as those of Suffolk or Sheppey and a retreating and changing outline; but few projecting pinnacles or rock-stacks. The waves sweep everything away before them. Where, however, we get even moderately hard rocks at the sea-margin we at once have very different shores. Here the coast rises in abrupt cliffs descending into deep water, or a pebbly shingle extends at their feet: there foam-tossing breakers indicate the submerged skerry; and there again rises perchance a solitary pillar marking the former line of shore, or with a neighbouring natural arch indicating its origin.

At the western extremity of the Isle of Wight are the well-known Needles and the former continuity of the chalk downs of the Island with those of Dorsetshire—ere the sea broke its way into the valley of the Frome, converting it into what we now know as the Solent—is marked by the similar pinnacles, Old Harry and his Wife, the Spiral Rock and the Barns, off Bollard Head on the opposite coast. The chalk of which the Needles are composed has been tilted, so that its once horizontal beds are now nearly vertical, and of the "joints" or divisional planes by which it is traversed in addition to its bedding-planes—due, also, as many geologists believe, to the strain to which the rock has been subjected—the dominant ones, the "master-joints," though at right angles to the bedding, rise also almost vertically from the water. These two sets of divisional planes have determined the direction of Nature's quarrying, as surely as they determine that of man's work in every freestone pit or in every coal-mine. But what has been the quarrying agency? At first we might be inclined unhesitatingly to attribute it to the sea.

The precipitous Old Red Sandstone cliffs of Caithness and the Orkney and Shetland Islands, graphically described by Dr. Archibald Geikie, furnish apparently still more striking instances of marine action. Here in the Race of Pentland we have the full fury of the Atlantic. "On the calmest day some motion of air always keeps playing about the giddy crest of the precipices, and a surge with creaming lines of white foam meets at their base. But when a westerly gale sets in, the scene is said to be wholly indescribable. The cliffs are then enveloped in driving spray torn from the solid sheets of water which rush up the walls of rock for a hundred feet or more." The mere weight of water in these waves is amply sufficient to detach fragments of rock, amounting as it often does to three tons on the square foot; but the action is enormously intensified by the existence of crevices or fissures in the rock. Every such cleft or chink becomes, as it were, a hydraulic press, in which the in-rushing wave acts on every side with a force equal to that with which it strikes the face of the rock. Perhaps even more effective, however, than this direct pressure of the water is the alternate compression and expansion of air which it produces. It was such suction of a retiring wave that, during a storm in 1840, burst a door of the Eddystone Lighthouse outwards; and it is, no doubt, such suction that starts large blocks of well-built masonry from their places, and will rapidly enlarge a cavity so commenced. It is this action probably that mainly explains the quarrying of blocks over 13 tons in weight out of the solid rock at 70 feet above sea-level on the Bound Skerry, in the Shetlands, and the hollowing out of long tunnels or "blow-holes," even in granite coast-lines, as in the Bullers, or boilers, of Buchan. Dr. Geikie and other competent judges tell us, however, that the

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fusillade of shingle hurled repeatedly against the cliffs is probably yet more destructive than either the weight of water or the compression of air.

Surely, then, when we find cliffs actually overhanging, as do those of the Brough of Birsa, in Orkney, or the Needles themselves, it is a sign of the undermining action of the ocean. But no; probably in every such case it will be found on examination that the rock forming the cliff has joints or other divisional planes inclined at a high angle inland. Joints or other divisonal planes, pre-existent in the rock, and only revealed by the denuding agent, determine, in fact, much of the outline of many very varied kinds of rock-pinnacles. Thus, in spite of such waves as those in the Pentland Firth above-mentioned, the Old Man of Hoy towers above the adjacent cliff from which it has been separated, a column of yellow and red sandstone more than 600 feet high, and almost four-square in its sharpness of outline. It consists, as described by Dr. Geikie, of almost horizontal beds of Upper Old Red Sandstone, resting on a pedestal composed of volcanic rock above and of inclined Caithness flags below.

So also the limestone stacks off the south coast of Pembrokeshire withstand the force of the Atlantic, though the lines of bedding and jointing with which they are marked tell a plain story of their former connection with the shore, a story confirmed by natural arches such as that known as "London Bridge," which are simply intermediary stages between the buttress and the pinnacle.

Overhanging cliffs, however, are rare; perpendicular ones, far from common. In the majority of cases we find they recede upwards: their upper portion wastes more rapidly than their base: subaërial action is, in fact, more potent in its more silent operation than all the combined terrific forces of the ocean. The pulverising action of the sun evaporating absorbed water, the wind, which sometimes tears large stones off the face of a cliff, and, above all, rain and frost are the agencies at work. Here, again, joints are of the utmost importance. It is down the joints that the rain mainly percolates; and it is thus along the joints that the winter's frosts flake off layer after layer from our cliffs, irrespective of the mineral composition of the rock.

Subaërial action being thus more powerful than marine, we might expect to find rock-pinnacles resulting from its agency elsewhere than along our sea-coasts; and so, indeed, we do. In many of the beautiful dales of Derbyshire, where rivers have excavated for themselves deep channels in the Mountain Limestone, huge buttresses of this rock project from the sides of the ravines, and some of these buttresses sometimes stand out detached from the side wall of rock as solitary pinnacles. Here the bedding is approximately horizontal, but rain-waters containing carbonic acid and frost have acted first along one set of joints, thus producing the buttresses, and then along the other set (there are commonly two) at right angles, so converting a buttress into a detached pinnacle. A precisely similar origin explains the Devil's Chimney, the detached pinnacle of oolitic limestone that stands in front of the Cotteswold escarpment near Cheltenham; or the Pulpit Rock of chalk at Bonchurch; though these latter have perhaps to some extent been undermined and have slipped forward in consequence.

Where the Elbe cuts its way through the Erzgebirge into Saxony we have, in the Saxon Switzerland, somewhat similar results in sandstone. Innumerable pinnacles rise above the forests, showing distinctly their horizontal bedding, but cut out into blocks by their joints as if built up of gigantic masonry.

Granite "weathers," as the geologist terms this decaying process, in a similar manner. Though not stratified, it is frequently traversed by joints in horizontal as well as in vertical directions, along which the disintegration acts. Hard and indestructible as it appears, a very slight study of granitic districts shows us that it is far from being as independent of the weather as it seems. Whilst microscopic examination exhibits incipient alteration of the felspar of much granite near the surface into china-clay or kaolin, one can go into many a pit on Dartmoor and find what appear to be walls of granite rotted into a gravelly consistency, quartz, mica, and felspar embedded in soft clay resulting from the decay of the latter. Such decay is generally explained by the action of carbonic acid in rain-water. This converts, it is said, the silicate of potash into a soluble carbonate and leaves behind the silicate of aluminium in a hydrated condition—in fact, as clay. There are, however, difficulties in the way of so simple an explanation, and M. Daubrée has maintained that some fluoride, probably hydro-fluoric acid (which might well be supplied by the tourmaline, fluor, or lepidolite that are not uncommon as accessory minerals in granite areas) has been the chief agent in attacking the felspar.

Be the agency what it may, granite weathers on the summits of hills into remarkable piles of stones, the well-known "tors" of Dartmoor and of Cornwall, that rise from the rounded hill-tops like irregular fortifications or "Druidic" monuments. Hey Tor, Rippon Tor, and Helmen Tor are familiar examples of such stone-heaps; whilst the Cheesewring, north of Liskeard (a granite pile about fifteen feet in height), is further interesting from having been considerably undercut, being thus far wider across above than at its base. This decay along horizontal joints, sometimes accompanied perhaps by the action of blown sand, has so undermined some of these rock-masses that they can be rocked with ease upon their natural pivots. This is the case with several of the stones on Helmen Tor and with other granite masses in Devon and Cornwall, to which the generic name of Logans is applied. The best known of these is that near Castle Treryn, St. Leven, a mass weighing about 65 tons and over 30 feet in circumference. It rocks only in one direction, and loose gravel scattered over the pivot indicates the wear and tear still in progress.

The mention of this gravel brings us to the consideration of one agency very important even when acting alone, viz. wind-blown sand. In our climate it is difficult to eliminate rain and frost; but there are cases in which we may perhaps safely put down the greater part of the action to sand. Naturally these are among sandstone rocks. Near Pateley Bridge, Harrogate, are the Brimham Rocks. They are composed of Millstone Grit, the various layers of which differ considerably in compactness. The harder layers project as ledges; but those near the top of the detached pinnacles project far beyond the base, around which there is a plentiful supply of loose grit. One of these rocks has been cut by Nature into the semblance of some huge misshapen idol, and another is appropriately named the Pulpit Rock. More than one of them can be rocked. To realise the cutting effect of the blown sand, it is only necessary to hold one's face near the base of one of these exposed monoliths during a high wind.

Quartz sand, propelled by a steam blast at a pressure of 300 lbs. per square inch, will, in 25 minutes, bore a hole $1\frac{1}{2}$ inches in diameter and $1\frac{1}{2}$ inches deep in a solid block of corundum or sapphire, though this substance is 9 in von Mohs' scale of hardness, whilst the quartz is but 7; and though wind in a strong gale, travelling 70 miles per hour, exerts a pressure of only 16 lbs. per square foot,

yet the potency of sand under its influence upon sandstone cannot be gainsaid.*

The softer sandstones of the Hastings series in the south-east of England lend themselves readily to this process of weathering, as is well seen in the neighbourhood of Tunbridge Wells, at West Hoathly, and elsewhere in Sussex, and has been well illustrated in Mr. Topley's *Geology of the Weald*. On Rusthall Common, Tunbridge Wells, stands the Toad-rock, one of the most striking of such pinnacles. Situated in a hollow on the upland

The Toad Rock, Rusthall Common.

heath, surrounded by low cliff-like exposures of the same sandstone, this rock-mass shows very plainly the effects of the greater impregnation of some of its layers with iron-oxide in resisting the weather, and the action of the sand. Its base is ankle-deep in white sand; and as surely as we attribute the pot-hole, hollowed in the hard rock beside the bed of the mountain torrent, to the gyrations of the pebbles that now lie within it in the eddies of the stream, so surely do we assign to this sand, whirled round the pedestal of the toad-like mass, the grooves cut all round this pedestal as if turned in a lathe. Harrison's Rocks, near by, are but a less complete exemplification of the same process. At West Hoathly it is in the same series of sandstones—the upper beds of the Lower Tunbridge Wells sand, a sub-division of the Hastings series—that the rock-pinnacles, now in the private grounds of Rockhurst, occur. "Great-upon-Little," the most famous

Harrison's Rocks, near Tunbridge Wells.

mass, is estimated to weigh between 400 and 500 tons, and is so poised upon its undercut pedestal as to be slightly movable. Though there has here been some slipping, the isolation of the great blocks can be seen to be primarily due to weathering along joints. It is interesting to notice here, in the shady hollows, the Filmy Fern (*Hymenophyllum tunbridgense*) which once graced the sister pinnacles of Kent.

It is probably to entirely similar causes that we may attribute the often erroneously described Agglestone of Studland Heath, Dorsetshire. Tradition tells us that this mass of iron-shot sand, estimated to weigh 400 tons, was dropped by the Prince of Darkness himself, chief of all "aggles," hags, witches or warlocks, who had intended it for the destruction of Wimborne Minster or Salisbury Cathedral. "Guide" books speak of it as "druidical," and geologists, who can never have examined it, as a transported "Sarsen-stone." A slight examination of the steep little conical hillock, resembling a tumulus, on which it is perched, reveals the fact that it is part and parcel of this said mound, and is, in fact, but an extra hard portion of those Bagshot sands that form the whole heath and crop out so picturesquely in the Painted Rocks of Studland Bay. The resistance of a strongly impregnated iron-sand to the weather is the secret of its existence.

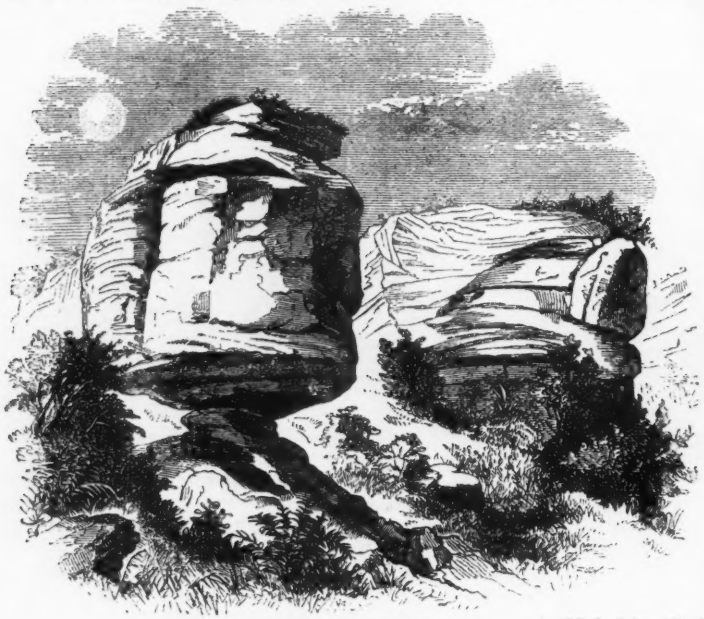
Did we go farther afield, to the arid plateaux of Colorado, we might find written yet more legibly, because not so obliterated by rain or frost, the tale of Nature's sand-blast. Here level plains, thousands of square miles in extent, intersected by cañons carved perpendicularly thousands of feet down through horizontal limestones, sandstones and shales, have been lowered by the removal of strata thousands of feet in thickness. The proof of this lies in the many-coloured cliffs whose projecting sand-polished ledges were the home of the ancient cliff-dwellers,

* The cutting power of sand, like the force of a blow, varies with the square of the velocity of the missile—according to experiments described at the Meteorological Society's meeting in May last by Mr. W. H. Dines. It was found that a pressure gauge, made to whirl round at the end of a long arm by steam power, registered a pressure of 1 lb. per square foot with a velocity of a little more than 17 miles per hour. Consequently, a wind of 69 miles per hour (which would be a very exceptionally high wind for England) would give a pressure of about 16 lbs. per square foot, and a pressure of 300 lbs. per square inch would be given by a wind blowing with a velocity of 850 miles per hour. I am not disposed to attribute such cutting power to sand blown by winds as Professor Boulger seems inclined to. The sharpness of many Egyptian carvings and inscriptions which have been bombarded by desert sand for 3,000 years is very remarkable. They are, however, generally cut in very hard rock, and have not been exposed to frost and rain.—A. C. Ranyard.

Note on Mr. Ranyard's Note.—It is perhaps the undercutting that most clearly exemplifies blown-sand action, this not being, I think, explicable by mere rain and frost. The examples I have quoted are in sandstone or limestone, not in granite or harder rocks.—G. S. Boulger.

and in the flat-topped, perpendicular-sided "buttes," or outliers, that still rise above the wind-swept plains.

We have not even yet exhausted the causes that may give rise to rock-pinnacles. The Finsterbach, near Botzen in the Tyrol, flows down a steep-sided ravine about 200 yards across and 400 to 500 feet deep, excavated in a glacial moraine of red mud, containing many large stones. Rain beating down upon the banks of this ravine, which slope at an angle of more than 30°, has washed away much of the mud; but each stone protects the earth beneath it, and, in so doing, becomes the capstone of a mud-column. Hundreds of these columns, or "earth-pillars," line the flanks of the ravine, of every height and age. Nor is this



Great-upon-Little, West Hoathly.

case, drawn by Sir J. F. W. Herschel in 1821, and described by Lyell in 1857, altogether exceptional. Besides other instances in the same district and in the Valais, Dr. Geikie has figured precisely the same thing cut out of a conglomerate of Old Red Sandstone age, at Fochabers in Strathspey, and on a miniature scale it is a phenomenon that can often be noticed. On the leeward of a gravel bank the pebbles may often be seen capping miniature pillars of sand, perhaps an inch or two in height. But what signifies the scale on which she operates? Nature's laws are as well exemplified in small things as in great; and here in the action of rain alone, cutting vertically, we have yet one more of her manifold processes for the manufacture of rock-pinnacles.

MAIL-CLAD ANIMALS.

By R. Lydekker, B.A. Cantab.

AMONG civilized nations throughout the world the practice of protecting their fighting-men by coats of mail, which prevailed so extensively during the middle ages, has been entirely abandoned; the cuirass of the English Household Cavalry and of the French Cuirassiers being a survival, or, as Naturalists would say, a rudiment, of the complete coat of mail, which is retained more on account of the smartness which it adds to the equipment than for any practical use as a protection. The use of armour as a protection has, indeed, been transferred from men's bodies to the sides of ships of battle; and even there it appears problematical whether the ever-increasing weight of the armour which is necessary to keep pace with the development in the size and speed of the missiles employed against it will not eventually, as was the case with human armour, become so burdensome as to lead to its abandonment.

In the case of the coats of mail of the mediæval warriors a gradual process of evolution had, indeed, brought them to a marvellous pitch of perfection at the time when they were once for all abandoned; and the beauty of the suits of chain- and plate-armour, both as works of art and as admirable adaptations for their particular purpose, must at once strike all who visit a gallery of ancient armour.

If now we direct our attention to the animal, as distinct from the human, world, and confine our survey to that portion of it which includes the back-boned, or, as Naturalists term them, the vertebrate animals, we shall find in the early periods of the earth's history a great tendency in many groups to the development of a coat of mail, fully as beautiful, and frequently much more efficient than that of the knights of old. We shall find, moreover, that on the whole vertebrate animals have, so to speak, come to the conclusion that a coat of mail is not altogether an advantage, more especially among the higher forms, in the struggle for existence; and that a better protection is to be found in the swiftness of limbs for flight, or in the length of teeth and talons for attack. Still, however, there are certain groups of animals which have preserved the old-fashioned plan of living and fighting the battle of life in armour, although even some of these seem to be in two minds as to whether, after all, the plan of facing the world with unprotected bodies is not really the best.

In drawing a parallel between human and animal armour we must, however, remember always that the animal has this inestimable advantage over man, that his armour is grown upon his own body, and is in fact part and parcel of himself, instead of having to be put on and off. Again, whereas the chief types of human armour may be summarised under the three forms of chain- scale- and plate-armour, we find a much greater variety prevailing in the coats of mail of animals. And here we would impress upon the reader who has followed us thus far, how much knowledge he would gain of these wonderful and frequently very beautiful structures if he were to visit the Natural History Museum at South Kensington, and inspect the admirable collection of different types of these and other marvellous animal structures arranged in the cases placed in the bays on the left side of the great central hall.

Our necessarily brief and hurried glance at some of the more important types of animal armour will be best understood if we take the various groups in their natural sequence of rank and their succession in geological time, commencing with the lower and earlier forms. Our first glance will then be directed towards the great class of fishes, of which some of the earliest examples occur in the Old Red Sandstone of Scotland, which was laid down in lakes and rivers ages before those forests flourished which formed the wood

and foliage we now burn in our fires as coal. Strange and uncouth must have been many of these old fishes, whose bodies were encased in a complete coat of plate-armour unlike that found in any living forms, and consisting of larger or smaller shield-like bones closely united together at their edges. The head, too, in some of these fishes (Fig. 1.) was most remarkable, and looked something like

FIG. 1.—AN ARMOURED FISH (*Cephalaspis*) OF THE OLD RED SANDSTONE.

a flattened and expanded plough-share. It has been suggested that the reason why these earlier fishes possessed such an extraordinarily strong coat of mail is that the waters of these primeval epochs were hot from contact with the still heated globe, and were also impregnated with strong acids or salts; but it does not appear that it would be any advantage to be boiled in a coat of mail rather than in an ordinary skin. Somewhat later in the world's history, that is to say at and about the period when our coal was formed, fishes with an armour of a different type were very abundant; many of the same groups also occurring in the Old Red Sandstone. In these Ganoid fishes, as they are scientifically termed, the body (Fig. 2) was often covered with

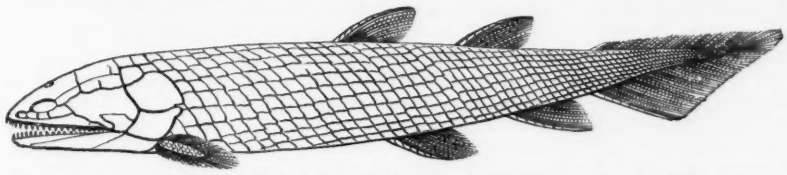


FIG. 2.—A GANOID FISH (*Osteolepis*) OF THE OLD RED SANDSTONE, SHOWING PLATE-ARMOUR.

a coat of lozenge-shaped scales, formed of bone and faced with a hard coating of shining and polished enamel. These scales did not, as in the fishes of the present day, overlap one another like the slates on a roof, but were joined together at their edges, frequently with the aid of a peg from one scale received into a socket in the adjacent one. Fishes with this form of plate-armour flourished not only in the Coal period but were also abundant at that later date when the blue Lias clays of the cliffs of Whitby and Lyme-Regis were laid down on the old sea-bottom. After that, however, this type of armour seems to have gradually gone out of fashion, and the only fish in which it now remains is the Gar-pike of the American rivers, which may thus be regarded as a kind of mediæval knight. The Sturgeons, known to many of us chiefly or entirely through that Epicurean luxury *caviare*, present us with another type of armour, which is probably a survival from long past days. In these gigantic fresh-water fishes the body is protected by several longitudinal rows of large diamond-shaped bony plates, which are not connected with one another. Whether, however, this modification of plate-armour is derived from a complete suit, and is thus somewhat analogous to the Life-Guardsman's cuirass, or whether it was always of the same type as at present, is one of those questions which does not at present admit of a decisive answer. In contrast to the Ganoid fishes, where we see a gradual dying out of the old mail-clad types, we may notice the case of the Sharks and Rays. These fishes seem to have taken a moderate course in regard to armour, avoiding on the one hand the plate-armour of the Ganoids, and on the other the light scale-armour of the fishes of to-day. In most of these fishes the skin is studded with very small bony granules, and thus has a rough file-like structure, being commonly known to us under the name of Shagreen. These fishes, be it noted, while among the earliest known forms, are still extremely abundant, and thus present a striking instance of the advantage of a middle course in the struggle for existence.

By far the great majority of the fishes of the present day belong, however, to a group which seems to have made its appearance shortly before our Chalk was deposited, and is now the dominant one. These modern fishes have succeeded in entirely getting rid of the plate-armour of the Ganoids, for which they have substituted a much lighter scale-armour formed of the well known over-lapping horny scales which give the silvery lustre we admire so much in the roach and salmon. The same type of armour also obtains in the Barramunda of Queensland (Fig. 3), which

FIG. 3.—THE BARRAMUNDA (*Ceratodus*) OF QUEENSLAND, SHOWING OVERLAPPING SCALE-ARMOUR.

belongs to an older group. Whereas, however, the majority of the fishes of the present day have adopted this light scale-armour in place of the old-fashioned plate-armour, a few have struck out a new line in the development of a different type of bony coat of mail. Thus the tropical Coffer- and File-fishes have a protective coat of bony plate-armour with a sculptured outer surface, so locked together as to form a box-like structure investing the entire body. Again, among the fresh-water Cat-fishes there is one genus in which the body is covered by a cuirass of overlapping plates formed of solid bone. Perhaps, however, the most peculiar kind of armour in the entire class is found among some of the well-known Globe-fishes, which are also so remarkable for their habit of inflating their bodies into a balloon-like shape. In these fishes, as is shown by a preparation in one of the cases already alluded to in the Natural History Museum, the body is protected by a coating of long spikes, each of which may be as much as two inches in length, and is inserted in the skin by a flat and expanded plate of bone.

As a whole, then, in spite of the exceptions last mentioned, which according to the time-honoured phrase only serve to prove the rule, the fishes appear to have come to the same conclusion as the more advanced divisions of the human race, that a massive armour for the protection of the body is an encumbrance rather than an advantage as a means of protection against attack.

The same story is told still more clearly in that group of animals now represented by the frogs, newts, and their allies, which are popularly reckoned among Reptiles, but which Naturalists, with that tendency to multiply terms for which they are so celebrated, distinguish as Amphibians. Thus during and for some time after that distant epoch to which we have already referred, when the coal forests waved over what is now Britain, there lived a number of newt-like Amphibians, termed, from the complicated internal foldings found in the teeth of many of them, Labyrinthodonts. In these creatures, of which the petrified footmarks are often found in the sandstones of

Cheshire, the under surface of the chest was protected by three large bony plates; while in some cases an armour of scale-like bones covered the rest of the body. All the existing frogs, newts, and such-like creatures have, however, totally dispensed with the panoply of their forefathers; and have, as we all know, a soft and naked skin.

The true Reptiles, in which the Naturalist includes crocodiles, lizards, snakes, tortoises, and turtles, as well as a host of fossil extinct forms, appear, speaking metaphorically, to have held divided opinions as to whether a bony coat of mail was or was not a thing to be retained as a permanency; since, while some extinct and early groups never had any armour, others have continued this protective covering in great perfection to the present day. Reptiles are, moreover, remarkable for the great variety of the kinds of armour which they have displayed in the course of a long career.

The Crocodiles offer the best living examples of reptiles with a plate-armour, recalling that of some fishes. In these fierce creatures, the back and upper surface of the tail is covered with a number of oblong bony plates buried in the skin and covered by horny shields. In the true crocodiles (which in India so many people will insist on misnaming alligators), this armour is confined to the upper surface of the body; but in some, although not in all, alligators, there was also a similar armour upon the lower surface. Since, moreover, most of the earlier fossil types had an armour upon both aspects of the body, it seems that crocodiles have, on the whole, found it advantageous to get rid of the lower buckler, so that to a certain extent they seem to have followed the general rule. It is, however, very curious to find that there were some fossil crocodiles which totally discarded their armour; and have since these altogether disappeared, it would seem that this radical change did not answer in this particular instance.

As first cousins of the crocodiles, we may briefly note, then, fossil reptiles to which, from the gigantic size of some of them, the name of Dinosaurs, or Terrible Lizards, has been applied. Some of these huge creatures, which far exceeded the elephant in bulk, had a bony armour which formed a solid cuirass over part of the back and loins; while in many cases the bony plates which covered the body were developed into huge spikes of more than a foot in length.

The Lizards and Snakes, which we may regard as advanced and highly specialised reptiles, having but little kinship with the old-fashioned Crocodiles and Dinosaurs, have, as a rule, discarded the plate-armour of the latter, and have acquired instead a light scale-armour of overlapping horny scales, which are beautifully marked in many of them. The snakes, indeed, never have any trace of the bony plate-armour, which would, of course, interfere with their lithe motions; but in some lizards, small rudimentary bony plates are found in the skin underlying the scales, to tell the tale of their old alliance.

Perhaps, however, the most original idea in the way of a coat-of-mail is found in the Tortoises and Turtles. In these reptiles, the ribs and back-bone of the skeleton have taken part with bony plates, analogous to those of the crocodiles, to form a solid armour which in the land-tortoises (Fig. 4) is welded together into a complete box, from which the creature can only protrude his head, tail, and limbs. This remarkable and unique arrangement has entailed the further curious modification that the shoulder-blade and haunch-bones are placed inside the ribs, instead of externally to them, as in all other animals. This type of armour, which we may term box-armour, seems to have been a success, since tortoises and turtles are, in certain parts of the world, among the commonest of reptiles. In some of those types which are dwellers in water, such as

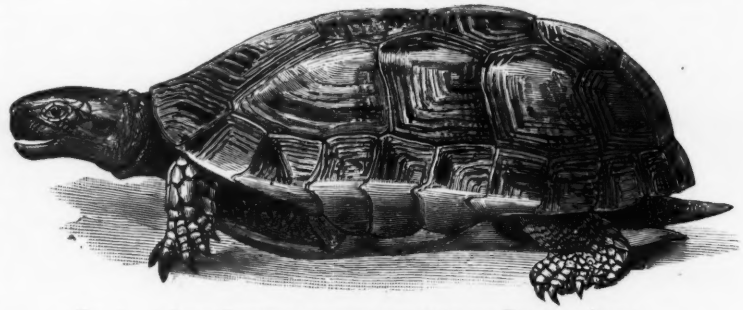


Fig. 4.—A Land-Tortoise, showing the complete Box-like Shell.

the well-known soft tortoises, or mud terrapins, so abundant in the Nile and other tropical and subtropical rivers, the breast-plate and the back-plate of the armour are, however, quite separate from one another, this arrangement, probably, being more conducive to freedom of action in swimming.

The great class of Birds, which Professor Huxley calls only highly modified reptiles, are remarkable in that there is no trace of a coat-of-mail in any single species. And when we come to consider the life which these creatures lead, we at once see the absence of any need for such a protection. Thus it is quite clear that in ordinary birds, which are gifted with the power of flight, a bony armour would not only be perfectly unnecessary as a protection but would also seriously impede, if even it did not totally prevent, their flight. On the other hand, in the flightless birds, like the ostriches and their allies, or the kiwis of New Zealand, sufficient protection is afforded either by their size and strength, or by their nocturnal habits. There are, indeed, certain flightless species, like the extinct dodo, of Mauritius, which have neither strength nor speed, nor are of nocturnal habits. Their want of the power of flight is, however, an acquired loss, due to their dwelling in islands in which they are, or were, free from the persecution of enemies, and thus needing no special protection of any kind.

Leaving the birds, we have to complete our brief and hasty survey of the various types of armour obtaining among vertebrate animals by a glance at that class which includes the highest of all vertebrates, and indeed of all animals. Unfortunately we are still in want of a good popular name for this class, which includes man himself. In common parlance these animals are, indeed, very generally termed quadrupeds. But this name is objectionable, in that it is equally applicable to many reptiles, and also since it can scarcely be applied to whales, which, as is well known, belong to the same class as man. The term Mammals is, however, becoming somewhat popularised in the sense of the older term quadrupeds, and, since it is in every way an excellent one, we shall make no apology for its use. Now, with the exception of one peculiar group or order, all mammals agree with birds in being conspicuous for the absence of a bony bodily armour; and since they have not the peculiar means of protection possessed by so many of the latter class, they afford striking examples of our thesis that as animals have progressed in organization they have discarded protection by plates of bone, to find a better one in the strength or

speed of their limbs, or in the sharpness of their teeth and talons.

The solitary group of mammals which has sought protection in a coat-of-mail is the one which comprises the sloths, ant-eaters, and armadillos. Only a few, however, of these creatures have thus protected themselves; while some, like the sloths, have sought refuge in an arboreal life; and others again, like the ant-eaters, have found protection by burrowing in the ground. These mammals, which are scientifically known as the Edentates, are all of a very low type of organization, and widely different from all other members of the class. It is, however, noteworthy that low as they undoubtedly are, yet that they exhibit no signs of relationship with the lowest of the mammal class, such as the Australian duck-mole. Since, moreover, the duck-mole and its allies have no coat-of-mail, it is further evident that the Edentates have not inherited their armour from lower forms, but that they have evolved it themselves *de novo*.

The Edentates having however, so to speak, once made up their minds that armour is the right thing have gone in for it with a will, with the result that they show some of the finest specimens of plate-armour to be found in the whole animal kingdom. In the comparatively small armadillos of America, which are the best known examples of the armoured Edentates, the whole of the body, with the exception of the under surface, is protected by a very strong bony armour, which is often elegantly sculptured. Thus their shoulders are encased in one solid shield, and their loins in another, the two shields being connected by a series of movable transverse bands, which permit the creature to roll itself up into a ball after the manner of a hedgehog, and thus present a sphere of plate-armour to an enemy. Still more wonderful, however, is the armour of the extinct Glyptodonts (Fig. 5) of South America, in

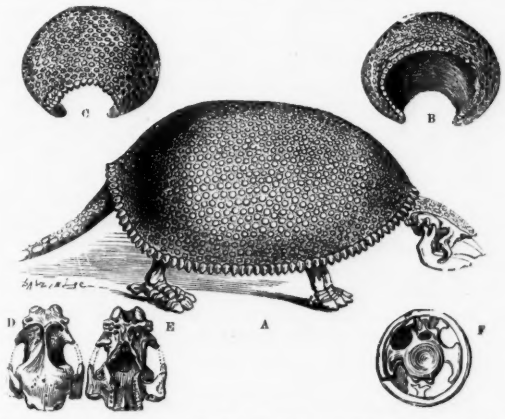


FIG. 5.—A GLYPTODONT EDENTATE, SHOWING THE CARAPACE. A, View of entire animal. B, Front end of carapace. C, Back view of same. D and E, Upper and under side of skull. F, Section of tail showing caudal vertebræ inside the bony sheath.

which the shield formed a single solid carapace, which may be as much as five feet in length, and with a thickness of more than an inch of solid bone. These creatures could not, of course, roll themselves up, and they therefore had their tails protected by a coating of bony rings closely articulated together. Moreover, some of them had a breast-plate on the under surface of the body, of which it is not very easy to see the necessity, since this aspect would not be exposed to attack. The huge carapaces of these Glyptodonts are often found on the Pampas, where they are said to be used as shelters by the natives. One would have thought that with such an armour the breed of Glyptodonts would at least have lived as long as the puny armadillos; but their extinction in long past epochs repeats the lesson that the race is not always to the swift, nor the battle to the strong.

Finally, as a last and very original type of mailed animals, we must mention the scaly ant-eaters, or pangolins, of Africa and Asia, which (pursuing our metaphor) appear to have come to the conclusion that a bony plate-armour is much too heavy for such warm climates, and have, therefore, adopted a light and elegant scale-armour composed of overlapping brown, horny scales, causing them to look much like an elongated cone of a spruce-fir endued with life. Even, however, this lighter and last type of armour does not appear to have been altogether a success in life's battle, since pangolins are comparatively scarce animals, few in species, and dragging on what seems to us a somewhat dull existence by the aid of nocturnal and burrowing habits.

THE COMMON FLEA.

By E. A. BUTLER.

NOTWITHSTANDING his elevated position in the animal creation, man is no more exempt—humiliating though the confession may be—from the attacks of personal parasites than other animals; but of the various species that link their fortunes with his, and subsist upon his person, fleas seem less dependent than any others upon uncleanly conditions and habits of personal neglect on the part of their host, and hence they are not restricted to the lower strata of society but become a universal nuisance. The ever-present desire to exterminate them, no doubt, operates powerfully against their being minutely studied, and hence very little seems to be generally known about their structure, habits, and life history, beyond what painful experience teaches. And yet they are really extremely curious creatures, and were it not for the popular prejudice against them, they would, no doubt, attract the attention they deserve: it is no exaggeration to speak of them as zoological oddities. There are many different kinds besides that particular species that infests man; they have been observed on various mammals, especially small ones with thick fur, or hair, such as moles, shrews, squirrels, mice, rats, dormice, hares and rabbits, as well as on dogs and cats. Many birds also are infested by true fleas, in addition to their own proper parasites, the bird lice. The species which attack these different hosts seem to be distinct, each animal, as a rule, supporting its own special parasite, but they resemble one another so closely that they form a perfectly natural family, which is called *Pulicidæ*, from the principal genus *Pulex*. On the other hand, in their most characteristic peculiarities they are utterly unlike any other insects, and hence have been a great puzzle to systematists. It is not easy to find a suitable corner for them in our schemes of classification, and many have got over the difficulty by placing them in an order by themselves, which, from the apparent absence of wings, has been called Aphaniptera (without distinct wings). Others have, however, seen in them some affinities to the two-winged flies, or Diptera, and have located them somewhere in that order; but here again there has not been unanimity, and some have placed them at the end, while others have inserted them in the body of the order, following the *Mycetophilidæ*, a family of small flies which possess considerable jumping power, and live gregariously amongst decaying vegetable matter, or in fungi,

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dung, &c. That their affinities are strongest with the Diptera is now generally recognised, and they are therefore regarded as a sort of apterous flies, which have addicted themselves to parasitic habits. The reasons for this opinion will become evident as we proceed.

Having premised thus much as to the zoological position of the group, we may now endeavour to get a clear notion of the structure of *Pulex irritans* (Fig. 1), the common human flea, so-called, and afterwards deal with its life history. In the shape of their body, fleas are quite exceptional; it is flattened from side to side, so that when the insect is standing upright its greatest diameter is the vertical one; this form of body is called "compressed"; it is exactly the reverse of what obtains in that other nocturnal pest, the bed-bug, whose body is flattened in the vertical direction, and whose greatest diameter is the transverse; this shape of body is called "depressed." Certain fishes present similar extremes of structure; thus a skate is depressed, but a plaice or sole compressed. The flea's body is covered with a hard, slippery, reddish brown chitinous skin, showing plainly enough the division into rings or segments which characterises insects and other annulose animals. The head, which is rounded above, is small in proportion to the size of the insect, and is followed by three small and separate segments which represent the thorax; these are again succeeded by several much larger segments forming the abdomen, which, in the female, is at least three times as deep as the head. To the thoracic segments are attached, as usual, the three pairs of legs, which increase in length from before backwards.

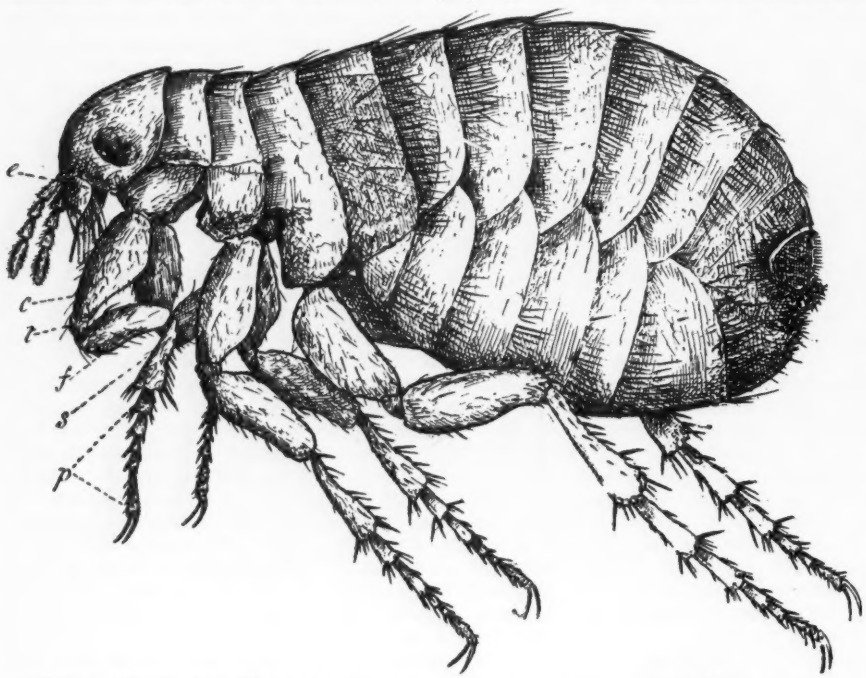

Fig. 1.—Common Flea (Pulex irritans), female; *e*, epimeron; *c*, coxa; *t*, trochanter; *f*, femur; *s*, tibia; *p*, tarsus.

The legs are remarkable in several ways. At first sight they seem to have an extraordinary number of joints, and yet the parts are exactly the same as in insects generally, and follow the plan typified in the cockroach. It will be remembered that that joint of an insect's leg by which the limb is attached to the thorax is called the coxa. Now the coxæ of a flea are not only enormously large, being indeed the broadest and almost the longest section of the leg, but they are also far more completely freed from the thorax than is usually the case, being only attached by one extremity; this causes the leg to appear to have an extra joint. But this is not all; in the first pair, especially, we seem to have yet another additional joint, and this appearance is due to the fact that the *epimera* (viz. those elements of the thoracic segment to which the coxæ are directly attached) themselves project from the body of the segment, and point obliquely forwards. These arrangements give an extremely awkward appearance to the legs, but no doubt facilitate the leaping process. The trochanter is small, and both femur and tibia are about the same length as the coxa; but the tarsus, which, like that of the cock-roach, consists of five joints, is remarkably long, and is terminated by a pair of long curved claws, which the insect must find extremely useful as it works its way about amongst the garments of its host, or between the bed-clothes. Most leaping insects have the hind femora very largely developed, since in them are placed the muscles which originate the impulse of projection; this arrangement is especially noticeable in grasshoppers, and in the tiny beetles called turnip fleas, which do so much harm to cruciferous plants. The hind legs of the flea, however, scarcely differ from the other pairs except in length, and the proportionate dimensions of all three pairs are much the same, all having coxæ larger than would be requisite for a walking insect. All parts of the legs are beset with bristly hairs, those towards the end of the tarsus being especially closely packed. The abdominal segments also are furnished with bands of long, stiff hairs across the back. No doubt these hairs—all pointing, as they do, away from the head—aid the flea, quite as much as its compressed form, in its endeavours to insinuate itself into the small spaces between our garments it has often to travel along in order to reach its pastures; and help, at the same time, to explain the difficulty that one experiences in attempting to hold the insect between finger and thumb.

Turning now to the mouth organs (Fig. 2), we find a far more complicated apparatus than might have been expected. The type of mouth is that called suctorial; *i.e.* it is adapted, as we are painfully aware, for the swallowing of liquid food, obtained by a process of perforation. In this respect fleas agree with flies, and, for the matter of that, with bugs; but are totally unlike bees, wasps, and ants, to which group of insects some people have thought they show some affinity. The labrum, or upper lip, seems to be represented only by a slender saw-edged bristle, which is perforated throughout its length by an exceedingly minute canal. This is situated in the centre, and

on each side of it are the mandibles, in the form of two straight flat blades, pointing downwards, and notched on each side like a double saw. The mandibular teeth number about 75 in each row on each side, which, at the rate of two double rows to each mandible, gives a total of some 600 glistening tooth-like projections on these

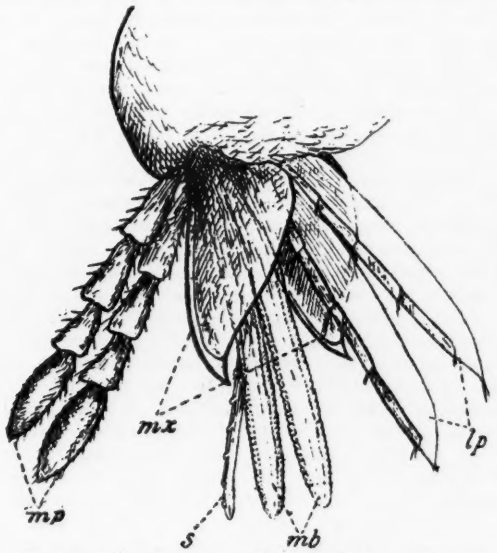

Fig. 2.—Mouth Organs of Flea; *s*, labrum; *mb*, mandibles; *mx*, maxilla; *mp*, maxillary palpi; *lp*, labial palpi.

weapons alone. The maxillæ are two sharp-pointed triangular pieces, which, when seen in profile, as in a specimen mounted for the microscope, have the appearance of a sharp beak; they are furnished with a pair of long four-jointed palpi, which project in front of the head, and might easily be mistaken for antennæ. The labium is reduced to a small membranous plate, which carries a pair of palpi, not quite so large as those of the maxillæ; each of these is formed into a keen blade on one edge, and rather obscurely jointed into four on the other. It is not easy to say exactly how these organs are used, since whenever we are consciously subjected to their operation, we are more anxious to get rid of the operator than to examine minutely into its method of proceeding. The whole evidently constitutes a piercing apparatus of exquisite delicacy, and the mandibles are no doubt the most effective part. We are accustomed to speak of *fleabites*, but this is scarcely a correct way of designating the operation; the appendages of the mouth are not in any sense biting organs; the action is that of vertical piercing, not lateral pinching or nipping. In possessing palpi fleas agree with flies, and differ entirely from the other chief order of insects with a piercing, suctorial mouth, viz. the bugs, which are never provided with such organs. On the other hand, in possessing both labial and maxillary palpi they differ from the ordinary flies, which are furnished with the latter only.

In the structure and arrangement of their organs of sense, again, fleas justify our statement that they are zoological oddities. While the eyes of flies are compound, each mass often containing thousands of facets, those of fleas are simple, and consist only of one rounded knob on each side; and as most of the insects' predatory operations are carried on in either partial or total darkness, it would seem that even these numerically reduced visual organs are of no great avail in the obtaining of food. The eyes are placed in the front of a hollow space, in the hinder part of which the antennæ are lodged; these are short, curiously shaped organs, and are so obscurely situated that they would certainly escape notice unless carefully looked for. (Fig. 3 represents the antenna of a dog's flea, and that of the human pest is very similarly shaped.) The hollow in which they lie is partially covered by an extension of the chitinous integument of the head, and the part still left open is further protected at a lower level by a membranous flap, which can be pushed aside when the antennæ are protruded. Their extraordinary shape, as well as their concealed and guarded position, indicates that many interesting problems await solution as to their functions and the particular uses of the several parts.

Fig. 3.—Antenna of Dog's Flea (Pulex canis). After Landois.

The last two thoracic segments carry a rounded scale on each side, projecting from their hinder edge. The first is a minute one, but the second very much larger, overlapping parts of the first two abdominal segments. They are apparently rudimentary wings.

Fleas sometimes exist gregariously on their hosts, and those of the lower animals especially have the habit of attaching themselves most pertinaciously to some part of the body from which no effort of their host can dislodge them. Some years ago, Mr. Verrall exhibited before the Entomological Society a colony of living fleas which had been taken shortly before from the inside of a rabbit's ear, where they were congregated on a spot from which the animal could not remove them by scratching. The neck of a fowl, again, is another place on which large numbers of a certain species have been found, collected in a small area, with their lancets buried deep in the flesh. They are not slow to discover when their host can furnish them with no further nourishment, and it is curious to notice how soon they abandon a dead body. This may easily be observed in the case of the cat's flea; if a recently defunct cat be watched, as the body becomes cold and stiff, the fleas will soon be seen struggling out from amongst the fur, though not a single specimen may ever have been seen as long as the animal was alive and warm, and its blood therefore readily obtainable.

The human flea is reputed to be pugnacious, and one observer, who had confined a couple of females in a glass tube, in order to induce them to deposit eggs, describes them as immediately becoming "rampant, confronting one another like microscopic kangaroos."

Fleas are peculiar amongst parasites as being parasitic only during one stage in their career. It is only the fully-grown insects by which we are troubled, and though we find them of different sizes, little ones and big ones,

it must not be supposed that the former are merely younger forms of the latter. A flea has not throughout its life the form with which we are familiar, nor does it in that form grow at all. The little fleas are simply the males, which are considerably smaller than the females, in accordance with a rule very frequently illustrated amongst insects. The males also differ in shape, and have the hinder end of the body somewhat turned upwards. In its life history a flea differs totally from a bug; the former is an insect with a complete metamorphosis, and therefore altogether differently shaped in its larval condition, while the latter is almost identical in shape during the whole of its life, and exhibits similar habits throughout; hence the tiny bugs are really young ones, though this is not the case with fleas.

(To be continued.)

ON THE SCINTILLATION OF STARS.

By A. C. Ranyard.

If a large star near to the horizon is watched by an ordinary long-sighted person,* it will be noticed that its light is not steady, but that three classes of changes are continually taking place. The brightness of the star increases and decreases. Its light changes in colour, and the central bright point appears to dance or jump about. All these changes put together make up the phenomenon known as scintillation or twinkling, which is so evident, even at considerable altitudes, that most people are able to recognise planets by the steadiness of their light which does not scintillate or twinkle.

In order to see the changing colours to the best advantage, let anyone direct a small telescope to a star not very far from the horizon, and, having focused it sharply, let him tap the eye-piece or body of the telescope so as to make it vibrate. To the observer the star will appear to move, and not the telescope. It will appear to be drawn out into a line of light as the eye follows the motion of the edge of the field of the telescope, and the star is projected upon different parts of the retina. If the telescope is a small one, and vibrates rapidly so that the period of its swing does not occupy more than about a third of a second, the star will appear to describe a closed orbit, generally either an ellipse or a circle, along which the different colours repeat themselves very brilliantly. M. Montigny of Bruxelles has utilised this method for comparing the amount of scintillation on different nights, and for the same stars at different altitudes. His instrument, which he calls a scintillometer, enables him by whirling round a small disc in front of the eye-piece to make the image of a star appear to describe a circle in the field of the telescope, upon the circumference of which he counts the number of times that the colours are repeated; and the rate of motion being known, he calculates the number of changes of colour per second.

* I am careful to restrict the description to what is seen by long-sighted people, for short-sighted people see the stars as discs or patches of light on the sky. They see a bright disc for a large star, and a duller disc of about the same diameter for a small star. Many people go through life without knowing that the stars are seen by their neighbours as points of light, and to such people the phenomena of scintillation are much less perceptible. If a long-sighted person wishes to realise how a short-sighted person sees the heavens, let him take an opera-glass and look at the stars with it when out of focus, and a short-sighted person may realise how a long-sighted person sees the stars by focusing the opera-glass until the star images all appear as bright points. He will then be able to see the phenomena of scintillation as described above.

Authorities differ as to the exact cause of scintillation. Let us, therefore, examine closely the facts that may be observed, and study the conditions under which the light of a star reaches us. If the spectrum of a star rising in the east be examined, darkish bands are seen rapidly traversing the spectrum from the blue to the red; and, on the other hand, in the spectrum of a star setting in the west the dark bands traverse the spectrum from the red to the blue end. When a star is on the meridian the bands sometimes traverse the spectrum in one direction, and sometimes in the other, and sometimes they swing alternately to and fro. We evidently have in the regular motion of the bands in the light of a rising or setting star a phenomenon connected with the earth's motion on its axis; while in the irregular motion of the bands in the spectrum of a star on the meridian we seem to have a phenomenon connected with the direction in which the winds are blowing. If there are masses which cause unequal refraction in the air, they would cause the light of the star to be concentrated in some places and turned away from others. If we consider only one of the rays of the spectrum, say a blue ray, and the light of the star were strong enough, it would illuminate a surface much as the shallow bottom of a rippling pool is lit up by the sun, causing light and dark mottlings, which appear to move along with the ripples on the surface. Each ray will be differently refracted, and consequently the blue and the red mottlings will overlap and be constantly changing. If we trace backward from the eye the different rays of the spectrum through the air it will be seen that the violet ray, which is most refracted, must have entered the air at a greater height than the red ray, and we may calculate the distance between the two rays at various altitudes. The different behaviour of the two rays shows that many of the refracting masses in the air are small compared with the separation of the different coloured rays, and that the refraction causing the dark bands in the spectrum must take place at a considerable altitude. This also is evident from other considerations.

The various coloured rays from the star are carried athwart the refracting masses as the star rises, and the violet ray will be the first to be affected by any particular refracting mass—it will then successively affect the blue, the green, the orange, and the red, and, as we have seen with a rising star, a dark band passes down the spectrum from the violet to the red end. We can calculate the rate at which these rays sweep across a refracting mass at any distance from the observer—as was explained in the article on Mountain Observatories in the April number, a line from a star to the eye of the observer sweeps onward like the hand of a great clock, which makes one revolution in twenty-four sidereal hours. At a distance of 25 miles from the observer the thwart motion of the rays through the air (if no wind were blowing) would be about 9 feet 7 inches per second, or a little more than 6 miles an hour — a velocity which is small compared with the average velocity of the wind in the upper air. Thus M. Angot gives the average velocity of the wind at the top of the Eiffel Tower—994 feet above the ground—as 16 miles per hour, while the average velocity during the 101 days of observation, measured with a similar instrument placed 66 feet above the ground at the Paris Meteorological Office, was only 5 miles an hour. At greater heights the wind velocity is probably still greater, for example, we know that the dust from Krakatoa was carried to Trinidad, half round the earth, in seven days, showing an average westerly velocity of 80 miles miles per hour. The regular drift of the dark bands in the spectrum of a rising or setting star shows that the

velocity with which the rays are carried athwart the refracting masses is large compared with the velocity of the wind, or rather is large compared with the velocity of the wind across the line of sight. At a distance of 50 miles from the observer the rays from a star sweep through still air with a thwart velocity of about 12 miles an hour, and at a distance of 100 miles from the observer with a thwart velocity of 24 miles an hour.

Let us now consider the separation of the different coloured rays coming from a star at different distances from the observer. Ketteler gives, in the *Fortschritte der Physic*, 22nd *jahrgang*, p. 179, the refractive index for the B ray on passing from vacuum into air at a barometrical pressure of 0·76 met. as 1·00029350, and the refractive index for the G ray, under similar circumstances, as 1·00029873. Dr. J. H. Gladstone, who has made the subject of refractive indexes a special study, tells me that Ketteler's measures, though dating back to 1865, are still perhaps the best in regard to the dispersion of gases. According to these measures, it may be shown that for small deviations the dispersion of the G and B rays amounts to about $\frac{1}{60}$th of the atmospheric refraction.

We know that at a height of 45° above the horizon the atmospheric refraction amounts to nearly 1′, at a height of 27° it is nearly 2′, and at a height of 10° it is about 5′, and the horizontal refraction ranges from about 34′ to 39′. Consequently the deviation between the G and B rays, at sea-level, for these altitudes is about 1″, 2″, and 5″ (34″ to 39″) respectively. The greater part of the deviation is caused in the lower atmosphere; we may therefore be sure that the actual path of the rays lies closer together than two lines inclined at the angle of dispersion with which the rays enter the observer's eye. Consequently, for a star at an altitude of 45° (at which altitude scintillation is very evident) the violet ray G of the spectrum will, at a distance of 25 miles from the observer, be within $7\frac{1}{2}$ inches of the red ray B, which, on reaching the observer's eye, will merge with the G ray in making up the image of the star. At a distance of 50 miles from the observer, the distance between the two rays will be less than 1 foot 3 inches. We know that the two rays suffer very different refraction—for one part of the spectrum is dimmed while the other is bright; we may therefore be sure either that the diameter of the refracting masses is small, or that the refraction is caused at a very great height in the atmosphere.

We have at our disposal another means of estimating, in a rough and general way, the diameter of the refracting masses which deflect the rays, much in the same manner as the distance between the waves on the surface of water might be estimated by a fish whose eyes would only permit him to look at the bottom. He might form an estimate of the average size of the waves, by observing the average distance between the bright and dark mottlings of sunlight on the bottom—so we may get some notion of the size of the refracting masses by looking at the disc of light which corresponds to the image of a bright star when out of focus in a large telescope. This disc of light is never perfectly uniform and tranquil; under certain conditions it seems almost to boil, the agitation is so great. Each part of the disc receives light from a different part of the object glass (or of the speculum, if the instrument be a reflector), and it is evident, from the dark patches continually passing across the disc, that less light from the star is falling on some areas of the object-glass or speculum than on others. With an 18-inch reflector, with which I have observed, one sees in the centre of the disc a black circular patch corresponding to the flat which reflects the light to the eye-piece. Dark and bright patches are continually passing across the luminous disc. As a general rule, they move parallel to one another. If they took a second to pass across the whole 18 inches, the actual velocity at right angles to the direction of the star of the refracting masses producing the patches would be a foot and a half per second, or a mile an hour. They usually pass more rapidly than this, but not so rapidly that the eye cannot follow them.

It has frequently been suggested that the refracting masses may be due to aggregations of aqueous vapour in the air; and it has been pointed out that the masses of aqueous vapour which become visible as cloud in the lower air are large, and that as you ascend the cloud masses become smaller and smaller; but the small refracting masses which produce the black bands which flit across the spectrum, and the black patches which move across the illuminated image of an object glass or speculum, cannot owe their difference of refracting power to excess or defect of aqueous vapour. If such aggregations of aqueous vapour were possible in the air, they would not produce the observed irregularities of refraction. For, according to Jamin (*Ann. Ch. Phys.* [3] xlix. 382), the difference between the refractive index of dry air and air saturated with moisture at 20° C. is only 0·000000726, a quantity which, as Dr. Gladstone (to whom I am indebted for the reference) says, "may safely be neglected for astronomical purposes."

But the difference in the refractive index of air is materially altered by a change of temperature—an increase of one degree Centigrade in the temperature of a mass of air increases its volume (the pressure remaining the same) in the proportion of 1 to 1·003665. Its density is therefore decreased in similar but inverse proportion, or as 1·003665 to 1, and we may calculate the change in the refractive index from the law $\frac{\mu-1}{d}$ = a constant.

In ordinary language this law may be stated thus. The excess of the index of refraction over unity, or the "index of deviation" (as Sir G. B. Airy happily christened the quantity $\mu-1$) varies as the density, or varies inversely as the volume of a mass of gas when the pressure does not change.

A decrease of temperature of one-hundredth of a degree Fahrenheit will cause a mass of air to decrease in volume in the ratio 1·00002036 to unity, and the focal length for parallel rays of a spherical lens of radius r and refractive index μ is $\frac{\mu r}{2(\mu-1)}$. Therefore a spherical mass of cooler air of one foot radius and one-hundredth of a degree Fahrenheit below the surrounding air, would bring parallel rays to a focus at a distance of $\frac{1\cdot00002036}{2(0\cdot00002036)}$ ft., that is, at a distance of a little less than five miles.

At a distance much less than five miles, or at a distance much greater than five miles, the concentration of light by such a spherical mass of cooler air would not make itself apparent; but the deviation caused in the direction of transmitted rays will be the same whether the mass of denser air is near or far from the observer.

We know, from the fact that the red and the blue rays coming from a star are very differently affected by the refracting masses, that they cannot be large in diameter compared with the distance between the path of the red and blue ray; and the small areas dimmed by them on the object-glass of a telescope also point to the conclusion that the masses are generally not many inches in diameter. We also know that the refracting masses which produce

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the bands that pass regularly across the spectrum of a rising or setting star must be very distant from the observer, or they would not in general be affected by the earth's rotation rather than by the winds blowing. We are therefore driven to the conclusion that the difference of the temperature, between the masses of air causing the unequal refraction and the surrounding air, must be small compared with the hundredth part of a degree Fahrenheit.

Notices of Books.

Diseases of Plants. By H. Marshall Ward, M.A., F.R.S. (Christian Knowledge Society.) We cannot conceive of a better introductory text-book on the subject of plant diseases caused by micro-fungi than this new volume of the "Romance of Science Series," nor could the subject have fallen into the hands of anyone better fitted than Prof. Marshall Ward to popularise it without in the slightest degree deviating from scientific accuracy. There is a freshness of style, a terseness and felicity of expression, and a lucidity of exposition that is quite fascinating, and that entices the reader on through chapter after chapter, as he follows the author in his description of the romantic adventures of first one kind of fungus spore and then another. A book which details with minute accuracy the life history of such scourges as the "potato disease," caused by *Phytophthora infestans*, the "hop-mildew," and the "smut," "rust," and "ergot" of cereals, cannot fail to be of interest and value to all practical men. If to be fore-warned is to be fore-armed, and if to know one's enemy is the best possible preparation for taking measures to protect oneself against him, then this book ought to be in the hands of every practical horticulturist and agriculturist of any pretensions, and to be diligently studied from end to end. The paper, typography, and illustrations are everything that could be desired.

Toilers in the Sea. By M. C. Cooke, M.A., LL.D. (Christian Knowledge Society.) This is something more than a mere popular exposition of the wonders of marine invertebrate life, and many who have long been students of the fauna of the sea will be grateful to Dr. Cooke for having gathered into convenient compass so complete an epitome of the results of modern research—results which are scattered through such a wide series of scientific journals that access to a good library and many hours of patient search are often necessary for the verification of facts. The scheme of the work has necessitated that only those groups of invertebrates should be included which possess solid parts capable of preservation in the dry condition, and in the investigation of which the microscope will be largely used; hence Foraminifera, Polycystina, Sponges, Sertularian Hydroids, Corals, Alcyonarians, Polyzoa, and Tube-worms are the only groups discussed. Notwithstanding Dr. Cooke's defence of the title he has selected, we still think that, as very few of the structures referred to are really marine "Homes without Hands," it would have been better to have avoided an expression which in almost every case suggests a wrong relation between the object described and the animal of which it formed a part. This, however, is a minor point, and there is little in the book itself but will tend to dissipate the too commonly received notion that such structures as coral, for example, are formed by the united *efforts* of numbers of minute creatures which *toilingly* raise, little by little, structures which ultimately reach gigantic dimensions. The book is delightfully written and well illustrated, and contains an enormous amount of information from the best possible sources. To amateur microscopists especially we would most cordially commend it, and we feel sure that if they will only take it as the companion to their favourite instrument, they will be able to form far more intelligent ideas concerning the nature of many of the beautiful objects which are popular in microscopical exhibitions, than are at present, unfortunately, generally to be met with.

Wayside Sketches. By F. E. Hulme, F.L.S. (Christian Knowledge Society.) This is a book of gossip, on an endless variety of subjects connected with rural life and the round of the seasons; but it descends, we fear, too frequently to the level of commonplace, and the chapters are far too long. The illustrations, nearly seventy in number, are a redeeming feature, being varied in subject, and, as a rule, accurate and artistic in execution.

GROWTH AND DECAY OF MIND.

By the late R. A. Proctor.

(*Continued from p.* 231.)

IT cannot be questioned that with old age there comes a real physical incapacity for original work, while the power of maturing past work remains comparatively but little impaired. Dr. Carpenter has shown how this may partly be explained by the physical changes which lead in old age to the weakening of the memory; or perhaps we should rather say that in the following passage his remarks respecting loss of memory serve to illustrate the loss of brain power generally, and especially of the power of forming new ideas, in old age. "The impairment of the memory in old age," he says, "commonly shows itself in regard to new impressions; those of the earlier period of life not only remaining in full distinctness, but even it would seem increasing in vividness, from the fact that the eye is not distracted from attending to them by the continued influx of impressions produced by passing events. The extraordinary persistence of early impressions, when the mind seems almost to have ceased to register new ones, is in remarkable accordance with a law of nutrition I have formerly referred to. It is when the brain is growing that the direction of its structure can be most strongly and persistently" (query lastingly?) "given to it. Thus the habits of thought come to be formed, and those nerve-tracks laid down which (as the physiologist believes) constitute the mechanism of association, by the time that the brain has reached its maturity; and the nutrition of the organ continues to keep up the same mechanism in accordance with the demands upon its activity, so long as it is being called into use. Further, during the entire period of vigorous manhood, the brain, like the muscles, may be taking on some additional growth, either as a whole or in special parts; new tissue being developed and kept up by the nutritive process, in accordance with the modes of action to which the organ is trained. And in this manner a store of 'impressions' or 'traces' is accumulated, which may be brought within the 'sphere of consciousness' whenever the right suggesting-strings are touched. But as the nutritive activity diminishes, the 'waste' becomes more rapid than the renovation; and it would seem that while (to use a commercial analogy) the 'old-established houses' keep their ground, those later firms, whose basis is less secure, are the first to crumble away—the nutritive activity, which yet suffices to maintain the original structure, not being capable of keeping the subsequent additions to it in

working order. This earlier degeneration of later formed structures is a general fact perfectly familiar to the physiologist."

One of the most remarkable features of mental development, characteristic, according to circumstances, of mental growth and of mental decay, is the change of taste for mental food of various kinds. Everyone must be conscious of the fact that books, and the subjects of thought, lose the interest they once had, making way for others of a different nature. The favourite author whose words we read and re-read with continually fresh enjoyment in youth, appears dull and uninteresting as the mind grows, and becomes unendurable in advanced years. And this is not merely the effect of familiarity. I knew one who was never tired of reading the works of a famous modern novelist until the age of twenty-five or thereabouts, when it chanced that he was placed in circumstances which caused novel-reading to be an unfrequent occupation, and in point of fact certain works of this author were not opened by him for ten or twelve years. He supposed, when at the end of that time he took up one of these works, that he should find even more than the pleasure he formerly had in reading it, since the story would now have something of novelty for him; and he had once thoroughly enjoyed reading it, even when he almost knew the work by heart. But he no longer found the work in the least interesting; the humour seemed forced, the pathos affected, the eloquence false; in short, he had lost his taste for it. In the meantime, the works of another equally famous humourist had acquired a new value in his estimation.* They had formerly seemed rather heavy reading; now, every sentence gave enjoyment. They appeared now as books not to be merely tasted or swallowed, but, as Bacon hath it, "to be chewed and digested." The change here described indicated (in accordance at least with the accepted estimates of the novelist and humourist in question) an increase of mental power. But a distaste for particular writings may imply the decay of mental power. And also, more generally, a tendency to disparagement is a very common indication of advancing mental age. "The old brain," says Wendell Holmes, "thinks the world grows worse, as the old retina thinks the eyes of needles and the fractions in the printed sales of stocks grow smaller."

Another singular effect of advancing years is shown by the tendency to repetition. It is worthy of notice that this peculiar mental phenomenon has been clearly associated with physical deterioration of the substance of the brain, because it may be brought about by a blow or by disease. Wendell Holmes, speaking of this peculiarity, remarks, "I have known an aged person repeat the same question five, six, or seven times, during the same brief visit. Everybody knows the archbishop's flavour of apoplexy in the memory as in the other mental powers. I was once asked to see to a woman who had just been injured in the street. On coming to herself, 'Where am I? What has happened?' she asked. 'Knocked down by a horse, ma'am; stunned a little; that is all.' A pause, while one, with moderate haste, might count a hundred; and then again, 'Where am I? What has happened?' 'Knocked down by a horse, ma'am; stunned a little; that is all.' (Mr. Holmes appears to have sympathised with the patient's condition.) Another pause, and the same question again; and so on during the whole time I was by her. The same tendency to repeat a question indefinitely has been observed in returning members of those worshipping assemblies whose favourite hymn is, 'We won't go home till morning.' Is memory, then," he proceeds, "a material record? Is the brain, like the rock of the Sinaitic Valley, written all over with inscriptions left by the long caravans of thought, as they have passed year after year through its mysterious recesses? When we see a distant railway-train sliding by us in the same line, day after day, we infer the existence of a track which guides it. So, when some dear old friend begins that story we remember so well, switching off at the accustomed point of digression; coming to a dead stop at the puzzling question of chronology; off the track on the matter of its being first or second cousin of somebody's aunt; set on it again by the patient, listening wife, who knows it all as she knows her well-worn wedding ring—how can we doubt that there is a track laid down for the story in some permanent disposition of the thinking-marrow?"

We seem to recognise here a process of change in the brain corresponding to that which takes place in the body with advancing years—the induration of its substance, so that it loses flexibility, and thus while readily accomplishing accustomed work, is not readily adapted for new work. Our old proverb, "You can't teach an old dog new tricks," indicates coarsely enough, but justly, the peculiarity, as well mental as bodily, to which I refer. There is not a loss of power, but a loss of elasticity. We see aged men working well in the routine work to which they have become accustomed, but failing where there is occasion for change either of method or of opinion. Again, one recognises this peculiarity in the scientific worker, whence perhaps we may regard it as a fortunate circumstance that the tendency of the aged mind accords with its faculties, so that old men do not readily undertake new work.

(To be continued.)

* Probably the best means of testing the development of one's own mind consists in comparing the estimate formed, at different times, of the value of some standard work. Of course, different classes of writing should be employed to test different faculties of the mind. A good general test may be found in Shakespeare's plays, and perhaps still better in some of Shakespeare's sonnets. As the mind grows, its power of appreciating Shakespeare increases; and the great advantage of this particular test is that the mind cannot overgrow it. It is like the standard by which the sergeant measures recruits, which will measure men of all heights, not failing even when giants are brought to be measured by it.

PERIODICAL COMETS DUE IN 1890.

By W. T. LYNN, B.A., F.R.A.S.

OF the four periodical comets which are expected to return next year, two are of well-established periods, and have been seen on several occasions; the other two have each been observed at one return, with a probability that it was seen on an occasion several revolutions earlier.

Brorsen's was discovered at Kiel on the 26th of February 1846. Its period is about five and a half years, and it was subsequently observed at returns in 1857, 1868, 1873, and 1879. Another will be due early in 1890.

D'Arrest's was discovered at Leipzig on the 27th of June 1851, it has a period of six and a half years, and was observed in 1857–8, in 1870, and in 1877. It escaped observation in the winter of 1883, but another return will be due next summer.

M. Coggia discovered a small comet at Marseilles on the 10th November 1873. The investigation of Prof. Weiss made it probable that this was identical with one detected by Pons on 23rd February 1818, but, though its period is probably about five and a half years in duration, it has not been seen since 1873. Returns, if that be the true period, were due in 1879 and 1884; and another will be expected to take place early next year.

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Mr. Denning discovered a comet at Bristol on the 4th of October 1881. This has been thought to be identical with a comet found by M. Blanpain on the 28th of November 1819. On this point M. Schulhof remarks (*Ast. Nachr.* No. 2401), "La comète appartient incontestablement au groupe* toujours croissant des comètes périodiques dont la durée de révolution varie entre 5 et 7 ans. Son identité avec la comète 1819 iv, pour laquelle Encke avait trouvé une révolution de 4·8 ans, ne peut pas être décidée. Malgré la ressemblance générale des deux orbites, que Mr. Chandler a reconnue le premier, les éléments sont trop différents pour que nous puissions nous prononcer en faveur de leur identité, avant d'avoir suffisamment fixé les éléments de la nouvelle comète, et recherché si, entre 1819 et 1881, elle a pu subir de la part de Jupiter des perturbations aussi considérables."

The last determination, I believe, of the orbit of Denning's comet is that of Mr. W. E. Plummer, published in No. 25 of *Copernicus* (vol. iii. p. 1), which makes its period 3,235 days, or about 8·8 years, so that as the perihelion passage in 1881 took place on the 13th of September, the next will be due soon after Midsummer 1890.

Prof. Winnecke suggested that Denning's comet might be identical with one seen (once only) by Goldschmidt on the 16th of May 1855, and which was also thought to have been identical with the lost comet of De Vico. But as Goldschmidt could only obtain one approximate position, neither of these conjectures admits of proof.

R. A. PROCTOR MEMORIAL FUND.

READERS of Knowledge will, no doubt, have noticed an announcement in many of the daily papers stating that the monetary affairs of the late Mr. Proctor have now been wound up by his administrator, and that the total sum available as provision for his widow and the seven children (four of whom are daughters, and one a little boy a permanent invalid from hip disease) is under £2,000. To the small income which this will produce there is to be added £100 per annum from the Civil List, which is, however, granted only during Mrs. Proctor's life.

The £2,000 above referred to as the value of the residue after the settlement of all debts, some of which were waived, has been produced by the sale of Mr. Proctor's copyrights. Mrs. Proctor and the eldest daughter have, under a satisfactory arrangement with Messrs. Longmans, retained a small interest in the works now in Messrs. Longmans' hands, including the *Old and New Astronomy*, which will shortly be completed. But the value of the interest retained (calculated on the basis of the sum given for the remainder of these copyrights by Messrs. Longmans) is included in the £2,000, as is also the money received for all the other copyrights, which were purchased on liberal terms either by Messrs. Chatto & Windus, or by Messrs. W. H. Allen & Co.

The money given immediately after the death of the late Mr. Proctor by the Royal Literary Fund, and the proceeds of five lectures given by Mr. W. Lant Carpenter, as well as gifts from other friends, have enabled the family, who, owing to the suddenness of Mr. Proctor's death, were absolutely without resources, to weather through the first year. But these funds have now been exhausted, and a committee is in course of formation which the many friends of Mr. Proctor are invited to join. Subscriptions to the R. A. Proctor Memorial Fund, and communications will be received by Mr. E. G. Mullins, Manager of the City Bank, Bond Street Branch.

Since the date of the announcement in the daily papers the following subscriptions have been received :—

	£	s.	d.
Wm. James Adams, Esq....	0	10	6
"E.A."	2	0	0
Mrs. Barrett	2	0	0
"J. A. B."...	1	0	0
Andrew Chatto, Esq.	5	0	0
H. P. Curtiss, Esq.	5	0	0
W. Henry Domville, Esq....	10	0	0
"W. D."	2	2	0
"A Friend	1	0	0
Professor Grant	2	2	0
Lord Grimthorpe	20	0	0
D. Hodgson, Esq.	1	0	0
Edmund Johnson, Esq.	1	1	0
Messrs. Longmans, Green, & Co.... ...	20	0	0
J. Mott Maidlow, Esq.	3	3	0
Miss Martin	2	0	0
G. H. Mellor, Esq.	0	10	0
R. Hay Murray, Esq.	5	0	0
"Planetoids"	0	10	6
T. Shaw Petty, Esq.	10	10	0
Oscar Rohde, Esq.	3	3	0
T. C. Sandars, Esq.	5	0	0
Wm. Schooling, Esq.	2	2	0
F. Stevens, Esq.	1	1	0
Col. N. G. Sturt	5	0	0
Mrs. Stowe...	0	5	0
Walter Weblyn, Esq.	1	1	0
Philip Williams, Esq.	1	0	0
	£113	1	0

And others promised.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

EXTRACT FROM A LETTER FROM PROF. C. A. YOUNG REFERRING TO REVIEW OF THE "GENERAL ASTRONOMY" IN THE NOVEMBER NUMBER.

To the Editor of Knowledge.

". . . . There is just one thing in the critique which I want to ask you to correct, because it does an injustice to others. My *printers* were to blame for only a very small proportion of the errata that occurred in the book. For most of them I am myself responsible. The preparation of the last half of the book (after p. 200) and the proof-reading of the whole was done by me in a time of great distress (owing to my son's illness); and though I do not plead this circumstance as an *excuse*, it is an *explanation*, at least in part. I really wish you would take occasion to say editorially that 'whatever blame may attach to the numerous errata in Prof. Young's *General Astronomy* belongs almost entirely to himself, and not to the printers,' or something to that effect. . . . "C. A. Young."

[Instead of making the announcement editorially, I prefer to let Prof. Young's letter speak for itself. It shows in a characteristic manner Prof. Young's extreme anxiety

* The group connected with the planet Jupiter.

not to do an injustice to anyone. The son to whom he refers received last year a powerful electric shock through his body from hand to hand, from which he still lies an almost helpless wreck, unable to rise, and hardly able to lift his arms. This is the illness to which the letter refers. We are now so widely welcoming the Dangerous Demon of Electricity, that the accident to this promising young electrician (whom I remember as an Eclipse observer in Colorado in 1878) cannot be too widely used as a warning.

[Our last number was not a fortunate one in which to allude to the mistakes of American printers. It contained a good many printers' errors—probably due to the fact that it was the first number printed by fresh printers.—A. C. RANYARD.]

COMPARISON OF PHOTOGRAPHIC EFFICIENCY OF TELESCOPES.

To the Editor of KNOWLEDGE.

DEAR SIR,—Visually, I presume there is no difference of opinion that the faintness of a star which may be seen with a telescope depends almost entirely on the square of the diameter of the lens, and is independent of the focus. If the seeing is very bad, of course the large glass labours under a slight disadvantage; but we are assuming reasonably good astronomical conditions. In looking for faint stars, we would naturally use as low a power as the telescope would bear.

Photographically, diffraction has very little to do with determining the size of the image of a star. The size depends chiefly on the steadiness of the air, the accuracy of the following, and the correctness of the lens. The formulæ expressing it must therefore be only approximate and entirely empirical. It has been found that under favourable conditions at Cambridge with a 3-inch camera lens, the images of the fainter stars were ·035 mm. in diameter. With an 8-inch camera they were ·028 mm., and with a 13-inch telescope ·047 mm. The two latter instruments were finished by the Clarks. If the same had been true of the former, the images would undoubtedly have been smaller.

If faint star images were always of the same size, the faintness of a star which we might detect by photography would be inversely proportional to the square of the aperture of the instrument and independent of its focus—the same as for visual telescopes. As stated in my former communication (in connection with the formulæ then given), this is perhaps hardly fair to the larger instrument, as an increase of focus gives slightly larger images, and a modification in the formulæ is therefore introduced.

In Cambridge, under favourable circumstances, with the 13-inch lens, the diameter of a photographic star image is about 2″.

As regards the Orion nebula, I have been more delayed than I had expected, as I find on close examination that our negatives show much more detail than I had at first supposed. This involves a good deal more work, but I am hoping to have my results in final shape in the course of a few weeks more.

Very truly yours,

W. H. PICKERING.

Harvard College Observatory, Cambridge, U.S.A.

[The diameter of 2″ mentioned by Prof. W. H. Pickering is very small, and would seem to show that at Harvard the atmosphere is occasionally very tranquil. With two instruments of equal diameter, one double the focal length of the other, we should expect the same atmospheric inequalities to cause double the swing in the longer focussed instrument, that is, the luminous image of a star would travel over an area four times as great on a photographic plate in the focus of the longer instrument than on one in the focus of the shorter instrument. But the disc and rings are of double the diameter, and, area for area, of one fourth the intensity in the longer focussed instrument. The actual difference in the diameter of the initial patch of photographic action needs to be determined by experiment, before photographs taken with different instruments can be used for comparing the tranquillity of the atmosphere at two stations.—A. C. R.]

To the Editor of KNOWLEDGE.

DEAR SIR,—A fireball of remarkable brilliancy was observed here on November 4th, at 7h. 55m. G.M.T. It appeared to the north and below the pole star. That portion of the heavens was considerably obscured by cumulus clouds, and the passage of the fireball was shown by a series of flashes as it passed the intervening clearer spaces, which might have been taken for flashes of lightning. So far as could be made out, a line drawn from β Draconis to Castor would roughly indicate its path, and it moved from a considerable altitude obliquely downwards toward the N.E. horizon.

When first seen it equalled Venus at greatest brilliancy, and rapidly increased in size and brightness. When below the pole it burst with an intensely brilliant flash, which illuminated the whole northern region, but instead of being dissipated as usual, a large portion, fully equal to Jupiter in brightness, and much brighter than a first magnitude star, continued its course towards the N.E. horizon. The moon, about eleven days old, was shining brilliantly at the time. The duration was not more than six or seven seconds, and the light was decidedly blue.

See also *Nature*, Nov. 14, p. 32; also *Nature*, Nov. 21, p. 60, which must all refer to the same, and may interest you.—Yours truly,

C. E. PEEK.

Rousdon Observatory, Lyme.

To the Editor of KNOWLEDGE.

SIR,—Possibly the following may now be of some interest.

Some years ago I was in a small brick house in the Kew Road, Richmond. In a room on the ground floor an ordinary "register stove" fire-grate, filled with coal, was covered from the back to the hearth with a piece of newspaper; over the lower two-thirds of this was placed a sheet of cut tissue paper, of a bright green colour, and on the upper two-thirds, over all, was a sheet of pink tissue paper. Thus about one-half of the green paper was placed between one-half of the pink paper and the newspaper, and in contact with both.

One morning I found that in the night the whole of the green paper, except a few scraps of the corners, had been reduced to ash; but the pink paper and the newspaper were uninjured, with the exception of a few small burnt holes.

The grate was in an outside wall, and on the outside of the wall was an iron rainwater pipe from the roof, cut off a foot or more from the ground.

I was careful to ascertain at the time that no one in the house could by accident or otherwise have done it. Any kind of trick was quite unimaginable.

I can only suppose that the cause was a slight electric discharge.

Yours faithfully,

128, Mount Street, W. T. S. PETTY.

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To the Editor of KNOWLEDGE.

DEAR SIR,—In the series of beautiful photographs of our satellite you have favoured your readers with in the October number, a striking feature seems to me to be clearly brought out, viz. the elevated region to the north-westward of Tycho; this is much beyond the projection of a segment of a sphere, corresponding to the moon's limb.

Is not this an indication of increased convexity towards the earth—a displacement of the moon's centre of gravity drawn out by the earth's attraction, earthward—which has resulted ultimately in retarding our satellite's axial rotation?

I merely offer this as a confirmation by the photographs of a theory previously upheld.

Yours truly,
W. WESTGARTH, jun.

[According to theory, the earth's tidal action on the moon would only cause the lunar diameter directed towards the earth to be about 250 feet longer than the diameter at right angles to it. Such a difference is far too small to measure with the largest telescopes, even if the two diameters were at right angles to the line of sight. Mr. Westgarth must not rely on measures made upon pictures printed upon damped paper, which may have been considerably stretched in lifting from the printing block.—A. C. R.]

THE STRIKE, IN ITS RELATION TO HEALTH AND LIFE.

BY ALEX. B. MACDOWALL, M.A.

LONDON was lately the scene of one of the greatest social conflicts of modern times. For some five weeks the din of battle resounded in our ears. The results of that fight are undoubtedly immense and far reaching, and they are not yet by any means fully manifest. We shall not here attempt a wide survey of the new situation, nor a resuscitation of the dry bones of controversy. Our scientific object is merely to inquire how the health and life of London have fared in the course of the unusual experience of this remarkable time. We shall confine our attention to the three months, July, August, and September. The Dockers' strike began about the middle of August, and ended about the middle of September.

Reflecting how large a portion of the community was involved; how the copious stream of wages to something like 100,000 workers was abruptly stopped; how the means of sustenance had to be found from new sources for about 250,000 persons of all ages, a large proportion of whom live continually on the brink of destitution even in prosperous times: one would be inclined to think, *a priori*, that disease and death would appear with a great accession of force.

Yet (dealing with the London of the Registrar-General), if we look at the first two diagrams here presented, showing, first, the deaths week by week (continuous curve), as compared with the corrected average * (dotted line curve), and the deaths of persons at different ages; then, the deaths from various kinds of disease, and other causes, also compared with the averages; we seem to look in vain for anything of the nature of "cataclysm."

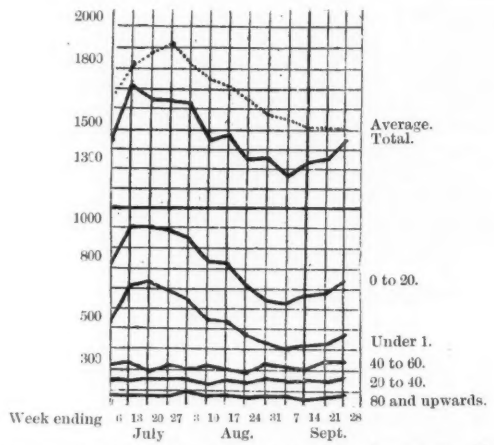


DIAGRAM 1.—WEEKLY DEATHS IN LONDON, JULY-SEPTEMBER, 1889.

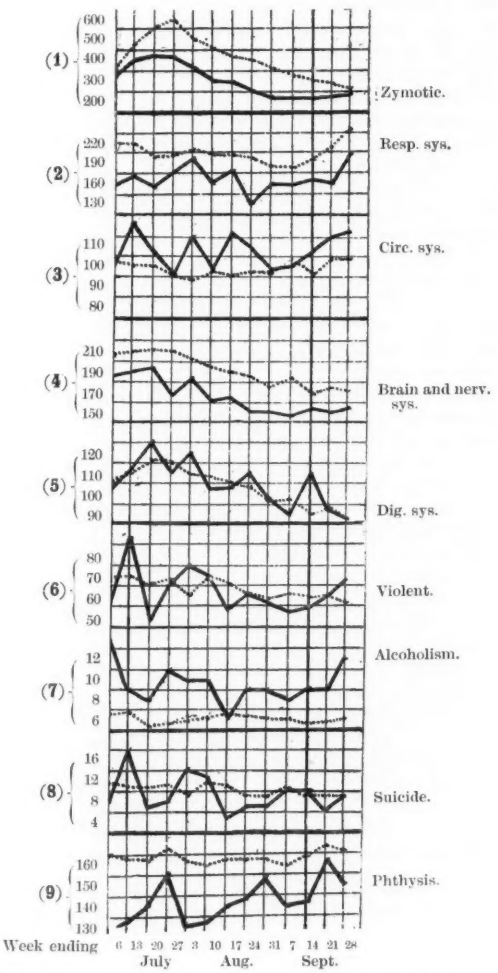


DIAGRAM 2.—DEATHS FROM VARIOUS CAUSES (LONDON).

Our second diagram, we may point out, is really a ver-

* By "corrected average" is meant the average weekly deaths for the ten years 1879–88, raised by 9·046 per cent. for increase of population.

tical series of smaller ones for different causes of death,* the scale varying according to convenience. The curves are made out from the official *Weekly Return*.

The death-rate, to begin with, has been throughout below the average. It certainly shows an increase (not very great) towards the average, from Sept. 7th, and one finds in a few of the disease curves (circulatory system, respiratory system, zymotic, violent, &c.) a rise about the same time, accounting for this increase. But, after all, the relation of those curves to the average (dotted line) curves remains in general good. None of the curves show any great excess over the average, and in most cases the total numbers after the commencement of the strike are under the total of the averages for the same time. We need not dwell much on details.

Of zymotic diseases, diphtheria is the only one that shows a continuous excess of deaths during those three months, and this is not, apparently, connected with the strike. The others show a mortality almost uniformly under the average.

The deaths from diseases of the circulatory system (heart disease, &c.), seem also to have been mostly in excess, but not more after the strike commenced than before it.

We give a curve of deaths from alcoholism (*i.e. delirium tremens*, &c.) The fact that the deaths assigned to this cause have been, not only in those three months, but throughout this year, nearly always in excess of the averages, might be worth the attention of those who are given to very glowing representations of our national progress in temperance (though we must avoid putting too great a strain on these figures). There is no evidence here of an increase of drunkenness during the strike. The drinking, indeed, was no doubt greatly diminished.

Perhaps we might expect an increase of suicides in such a time of pinch and anxiety. But the suicide-curve does not seem to be materially affected. Suicides are classed in the Returns with deaths from accident; homicides and execution under the head of violent deaths; and we may further note that there were nearly twice as many cases of homicide in the period before August 10 as in the longer period after it (17 as against 8). The increase in violent deaths from September 7 appears to have been chiefly in the section of "accidental deaths."

Is it merely a coincidence, or is it more, that directly after the two weeks ending July 13 and August 7, which show relative maxima in the deaths from alcoholism, come two weeks which show corresponding maxima in the number of suicides?

We find, then, on the whole, that the influence of the strike is not, thus far, very apparent. But, remembering that a population of two or three hundred thousand is but a fraction of the whole, it would be well if we could get facts bearing more closely on this portion. This we are enabled to do by the records of deaths in different districts of London—North, South, East, West, and Central. We show these in our third diagram; and as the East and West districts have approximately equal populations (the former had 692,738 in 1881, and the latter 669,633; and the West has probably grown more than the East since that date), we may with advantage specially compare these two, the one being closely affected by the strike, the other not. The fourth diagram shows the infant deaths in the same districts.

There is something of a divergence of those two curves (in Diag. 3) about the end of August. The rise then beginning in the East curve, as also that in the South somewhat later, may be partly connected with the strike. But it will be noticed that there is a general rise in other districts, such as the North and the Central, on which the strike can have had little or no influence; so that some more general cause or causes seem to be indicated.

If the result here again seems to be negative, we must bear in mind the limits of the case presented. Thus, *e.g.* it might very well be that the undoubted privations endured by many during the strike issued in the formation of a soil very favourable to the seeds of disease. The results in such a case might appear considerably later and be spread over a long time. Moreover, we have been dealing only with cases of illness which ended *fatally* in the period considered.

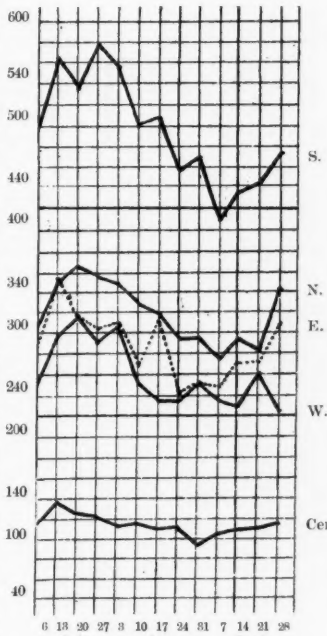


DIAGRAM 3.—DEATHS IN DISTRICTS.

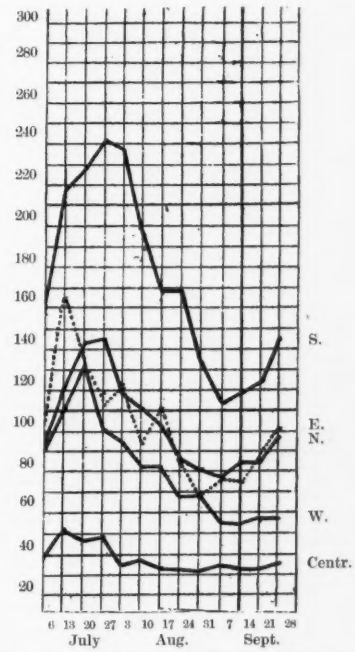


DIAGRAM 4.—INFANT DEATHS IN DISTRICTS.

On the other hand, we may recall the very favourable conditions of the strike—the splendid weather throughout, the extraordinary liberality of sympathisers (especially in Australia), the order in general maintained, the skill in organising commissariat, the credit given by tradespeople, &c. To not a few dockers it was probably a case of holiday in London, with regular food, and, in some instances, wholesome restriction of expenditure; and the personal and family deterioration, through squandering of wages in the public-house, must have been much reduced.

In reviewing the facts, it is evident that a great social revolution has taken place with vastly less derangement of the body-politic, in matters here considered, than would have been the case fifty or a hundred years ago.

* "Zymotic disease" here includes small-pox, measles, scarlet fever, diphtheria, whooping-cough, typhus, enteric fever, simple continued fever, diarrhœa and dysentery, and cholera. The chief diseases of the respiratory system are bronchitis and pneumonia; of the brain and nervous system, apoplexy and convulsions; of the digestive system, liver disease, dentition, enteritis, and peritonitis; of the circulatory system, heart disease, &c.

XUM

THE FACE OF THE SKY FOR DECEMBER.

By Herbert Sadler, F.R.A.S.

BOTH sunspots and faculæ continue to increase slowly in number. There will be a total eclipse of the sun on the morning of December 22, but it will not be visible in Europe. Conveniently observable minima of Algol take place on the 11th at 11h. 10m. P.M., on the 14th at 8h. 6m. P.M., and on the 17th at 4h. 49m. P.M. Mercury comes into superior conjunction with the sun at midnight on the 7th, and is invisible throughout the month. Venus is a morning star, but is getting fainter daily. On the 1st she rises at 5h. 53m. A.M., with a southern declination of 16° 45′, and an apparent diameter of 10½″. On the 31st she rises at 7h. 18m. A.M., 50 minutes before sunrise, with a southern declination of 23° 21′, and an apparent diameter of 10″. At 7 A.M. on the morning of the 10th she will be 6½′ due south of β Scorpionis, the two forming a close naked-eye pair. She does not approach any other conspicuous star very nearly. During the month she passes from Libra through portions of Scorpio and Ophiuchus into Sagittarius. Mars is a morning star, in Virgo throughout the month, but his diameter does not exceed 6½″, and, though increasing in brightness, the ordinary observer will make out nothing but a small gibbous red disc. On the 1st he rises at 2h. 20m. A.M., with a southern declination of 3½°, and on the 31st at 2h. 0m. A.M., with a southern declination of 10°. He is about 1° north of Uranus on the 24th and 25th. Jupiter has left us for the season. Saturn is now getting into a favourable position for observation, rising on the 1st at 10h. 41m. P.M., having a northern declination of 11½°, and an apparent diameter of 17¾″ (the major axis of the ring being 41½″ and the minor 5¾″ in diameter). On the 31st he rises at 8h. 37m. P.M., with a northern declination of 11° 39′ and an apparent diameter of nearly 19″ (the major axis of the ring being 43½″ and the minor 6¼″ in diameter). He is in Leo, to the east of Regulus, and is practically stationary throughout the month. On the evening of the 2nd Titan will be about 25″ *n.* of Saturn, and on the 10th about 26″ *s.* a little *f.* At 10h. 30m. on the 13th Iapetus will be 22″ due south. On the 18th Titan is about 28″ *n.p.*, and on the 26th about 28″ *s.f.* the planet. As Uranus does not rise till 1h. 40m. A.M. on the last day of the month, he is practically invisible to the amateur. Neptune is very favourably situated for observation, rising on the 31st at 3h. 32m. P.M., with a northern declination of 19° 5′, and an apparent diameter of 2¾″. On the 31st he rises at 1h. 32m. P.M. A map of the small stars near his path will be found in the *English Mechanic* for November 15th. He is in Taurus, and on the evening of the 23rd will be 19′ due south of the 6th magnitude star 43 Tauri. December is a fairly favourable month for shooting stars, the chief shower being that of the Geminids on December 9-12, the radiant point being in R.A.. V 11h. 0m. and declination 32°, rising about 4h. 10m. P.M., and setting at 1h. 40m. A.M. The moon is full at 9h. 52m. A.M. on the 7th, enters her last quarter at 2h. 58m. P.M. on the 15th, is new at 0h. 52m. P.M. on the 22nd, and enters her first quarter at 5h. 16m. A.M. on the 29th. On the 8th at 5h. 16m. P.M. the 3½ magnitude star η Geminorum will disappear at an angle of 56° from the vertex, and reappear at an angle of 241° at 5h. 1m. P.M.. At 9h. 34m. P.M. the same evening the 3rd magnitude star μ Geminorum will make a near approach to the lunar limb at an angle of 330° from the vertex. At 4h. 55m. P.M. on the 9th the 6½ magnitude star 44 Geminorum will disappear at an angle of 27° from the vertex, the moon being below the horizon of Greenwich at the time, and will reappear at 5h. 34m. P.M., the star being on the horizon at the time, at an angle of 282°. At 2h. 10m. A.M. on the 10th the 6th magnitude star 58 Geminorum will disappear at an angle of 80°, and will reappear at 3h. 33m. A.M. at an angle of 299° from the vertex. At 7h. 56m. P.M. on the 10th the 6½ magnitude star 7 Cancri will disappear at an angle of 70° from the vertex, and reappear at 8h. 51m. P.M. at an angle of 211° from the vertex. At 11h. 35m. P.M. on the 15th the 6½ magnitude star B.A.C. 4104 will disappear at an angle of 40° from the vertex, and reappear at 0h. 31m. A.M. on the 16th at an angle of 202° from the vertex. The same morning at 4h. 57m. A.M. the 5th magnitude star *c* Virginis will make a near approach at an angle of 130°. At 5h. 5m. P.M. on the 31st the 6th magnitude star B.A.C. 830 will disappear at an angle of 123°, and reappear at 6h. 3m. P.M. at an angle of 240° from the vertex.

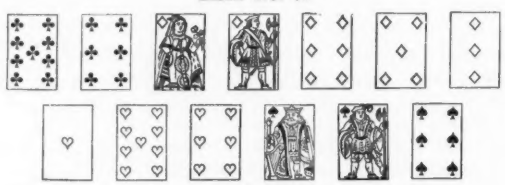
Whist Column.

By W. Montagu Gattie.

INFERENCE FROM AN ADVERSE DISCARD.

THE following hand, which occurred a few years ago in actual play, and was published at the time in the *Field*, furnishes an excellent illustration of the information that may be gained from an opponent's discard. The play of the hand is in other respects very brilliant, and quite worthy of the reputation of the late Mr. F. H. Lewis, who held A's cards, and in memory of whom we now reproduce the game. Mr. Lewis was a distinguished and enthusiastic whist-player, and an occasional correspondent of this paper. He will long be missed in London whist circles.

Hand No. 7.



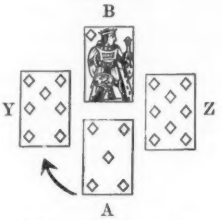
A's Hand.

Score—One All. Z turns up the seven of hearts.

Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

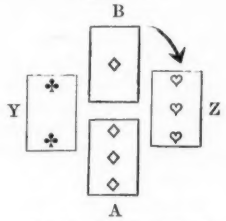
The notes appended to the tricks are supposed to be made during the play by the player whose hand is exposed. The subsequent remarks relate to the play generally.

Trick 1.



Tricks—AB, 1; YZ, 0.

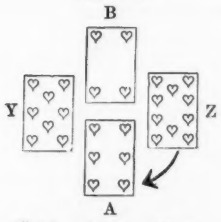
Trick 2.



Tricks—AB, 1; YZ, 1.

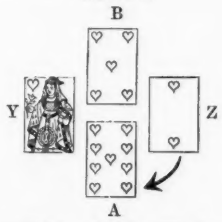
Note.—*Trick* 2.—Y is void of diamonds, and his discard of a club shows that his strong suit is spades.

TRICK 3.



Tricks—AB, 1; YZ, 2.

TRICK 4.

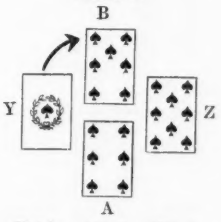


Tricks—AB, 1; YZ, 3.

NOTES.—*Trick* 3.—Y has either no more trumps, or the queen of hearts single.

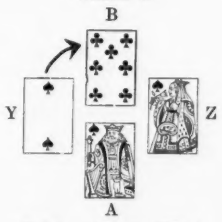
Trick 4.—Z's lead shows that the queen is with Y; but A, nevertheless, passes the trick in order that Y, who has shown strength in spades, may lead them up to king, knave, guarded. The remaining trumps are now marked in Z's hand.

TRICK 5.



Tricks—AB. 1; YZ, 4.

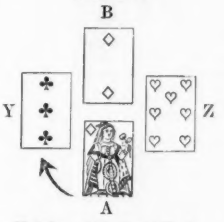
TRICK 6.



Tricks—AB, 2; YZ, 4.

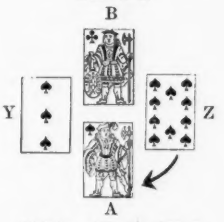
NOTE.—*Trick* 6.—A can now count the cards as follows: B has four diamonds, and three clubs all higher than the seven; Z has three trumps; and Y and Z have five spades between them, of which three at least are with Y.

TRICK 7.



Tricks—AB, 2; YZ, 5.

TRICK 8.

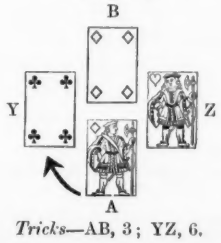


Tricks—AB, 3; YZ, 5.

NOTES.—*Trick* 7.—If A now leads out his ace of trumps, and if it should turn out (as is actually the case) that Z has four spades and so can put his partner in once more after drawing the knave, it is clear that YZ will make two tricks in spades and two trumps, and will consequently win the game. A, therefore, with admirable judgment, refuses to draw a trump, and prefers to continue the diamond force.

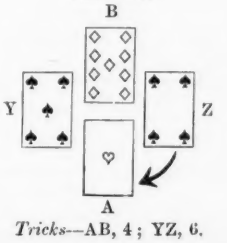
Trick 8.—B's discard determines A to continue his forcing tactics, and to reserve his ace for ruffing in the event of Z's having a fourth spade.

TRICK 9.



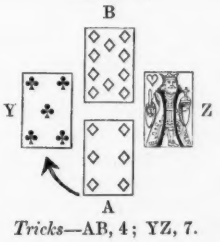
Tricks—AB, 3; YZ, 6.

TRICK 10.



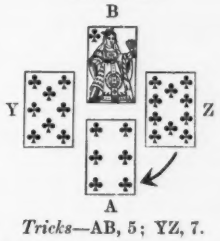
Tricks—AB, 4; YZ, 6.

TRICK 11.



Tricks—AB, 4; YZ, 7.

TRICK 12.



Tricks—AB, 5; YZ, 7.

Trick 13.—B makes the ace of clubs, and AB SAVE THE GAME.

A's Hand.	B's Hand.
H.—Ace, 9, 6.	H.—5, 4.
S.—Kg, Kn, 6.	S.—7.
D.—Qn, Kn, 6, 5, 3.	D.—Ace, Kg, 10, 9, 4, 2.
C.—9, 6.	C.—Ace, Qn, Kn, 7.
Y's Hand.	**Z's Hand.**
H.—Qn, 8.	H.—Kg, Kn, 10, 7, 3, 2.
S.—Ace, 9, 5, 3, 2.	S.—Qn, 10, 8, 4.
D.—7.	D.—8.
C.—8, 5, 4, 3, 2.	C.—Kg, 10.

REMARKS.—*Trick* 2.—As A must have at least three diamonds remaining, B, who himself has five, knows that one of the adversaries will fall short on the second round. His return of the ace is, however, quite defensible, seeing that he is very weak in trumps, although many players would have preferred to open the club suit. This latter course, as it happens, would have lost the game.

Trick 5.—Y plays badly in opening with his ace, especially as he has no card of re-entry. The rule that ace should be led from a five-suit does not apply when trumps are out. Y's proper play would be to lead his penultimate spade, and to finesse on the return of the suit. Z rightly puts on the eight instead of the four, so as to avoid blocking his partner.

Trick 6.—The ten of spades would have been rather better play on Z's part than the queen, since the king is marked in A's hand. It is worth noticing that a case here arises in which an American lead would be disadvantageous to the leader. If Y had continued with the three of spades, A could have placed five originally in his hand, and therefore four originally in Z's hand, and would have had much less difficulty in discovering the only way in which the game could be saved.

Trick 8.—B very properly discards his knave of clubs instead of a diamond, thus affording a valuable indication of the quality of his remaining clubs.

ELEMENTARY EXPLANATION OF THE PLAY.

Trick 1.—A opens his longest suit.

Trick 2.—B follows the ordinary rule in returning the ace at once. Y discards from his weakest suit. A can now count four diamonds in his partner's hand.

Trick 3.—Z leads from king, knave, ten; but, as the same card would be led from king, queen, knave, ten, A cannot tell, until Z leads again, whether the queen is with Z or with Y. But, as A himself has the nine, and king, knave, are marked with Z, Y's eight shows that he has the queen single or no more.

Trick 4.—Guided by Y's discard at trick 2, A determines to let him have the lead, so that he may open spades up to king, knave, guarded. The remaining trumps are marked with Z, for he turned up the seven, and his lead of the ten shows that he has knave and king.

Trick 5.—Ordinarily speaking, Y's lead of ace from a five suit is correct; but here he gives up the only card

upon which he can depend for regaining the lead and bringing in his small spades.

Tricks 6 *to* 12.—The whole point of A's play is to prevent Z from assisting Y to bring in the long spades. A's knave of spades blocks the third round (trick 8), and the ace of trumps is retained to block the fourth round in case Z should be provided with a fourth spade. This is a very interesting example of the importance, under certain circumstances, of abstaining from drawing a losing trump. After trick 6 B still holds four diamonds, and as he is void of trumps and spades, his other three cards must be clubs. His discard of the knave at trick 8 shows A that the two remaining clubs are honours, and that it is desirable to throw the lead into Z's hand, so that he may ultimately be forced to lead clubs up to B.

Chess Column.

BY I. GUNSBERG (MEPHISTO).

[Contributions of general interest to chess-players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

END-GAMES.*

When in 1851 Horwitz and Kling produced their book on End-games, they were well in advance of the time. Their interesting collection has held the field for many years, and is still unique in some respects, as many of the so-called "Studies" may be more accurately described as Problem studies, or Compositions. The literary tendency at the present time is, however, I regret to say, too much towards utilitarianism, and therefore the new work by Professor Berger, arranged systematically, on an academic plan of progressive study, may perhaps be considered a work of greater scope and utility from a student's point of view. But then we are not all students, we do not all of us burn the midnight oil in order to acquire the benefit of the latest laborious essay on the Ending of Rook against Rook and Bishop, we play Chess for pleasure and recreation; and although it is only natural that we should have some ambition to increase our stock of learning of our favourite pastime, for the sake of the greater pleasure which we may derive from greater knowledge, yet we should draw the line somewhere, and give preference to those books which combine amusement with instruction. The End-game Studies before us have that happy blend of instruction and amusement which will always please and never fatigue, and I venture to say, for that reason, they will continue to enjoy great popularity among English readers. Annexed are examples of Endings, which will best show the various kinds of studies, both useful and entertaining, contained in the book.

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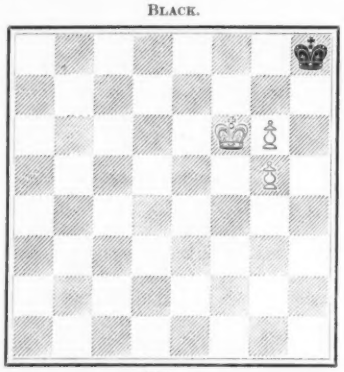

WHITE.

White with the move cannot win, but if Black moves first, White wins.

Solution.

1.	K to Kt sq
2. P to Kt7	K to R2
3. P Queens	K × Q
4. K to Kt6, and win.	

* *Chess Studies and End-Games.* By Horwitz and Kling. Second Edition. (G. Bell & Sons.)

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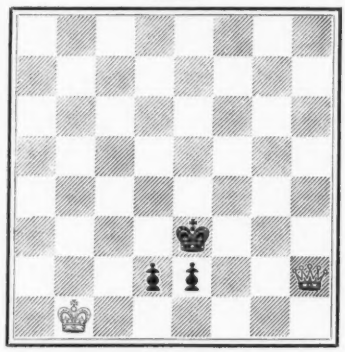

WHITE.

White to move and win.

Solution.

1. Q to R6 (ch)	K to Q6 (best)
2. Q to Q6 (ch)	K to B6
3. Q to B5 (ch)	K to Q6
4. Q to QB2 (ch)	K to K6
5. Q to B3 (ch) and wins.	

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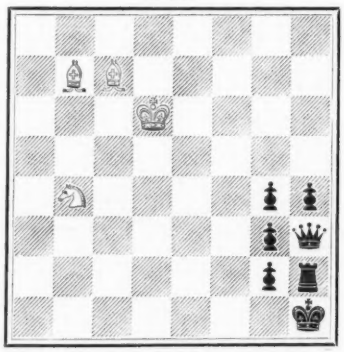

WHITE.

White to move and win.

1. Kt to B2	K to Kt8	8. K to Q2 (ch)	K to R8
2. B to Kt6 (ch)	K to R8	9. Kt to Q4	K to Kt8
3. K to B5	K to Kt8	10. Kt to K6 (ch)	K to R8
4. K to Q5 (ch)	K to R8	11. Kt to B5	K to Kt8
5. K to Q4	K to Kt8	12. Kt to K4	K to R8
6. K to K4 (ch)	K to R8	13. B to B5	P to Kt8 (ch)
7. K to K3	K to Kt8	14. Kt to B2 mate	

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Communications for the Editor and Books for Review should be addressed Editor of "KNOWLEDGE," care of J. MALABY, 67 Chancery Lane, W.C.

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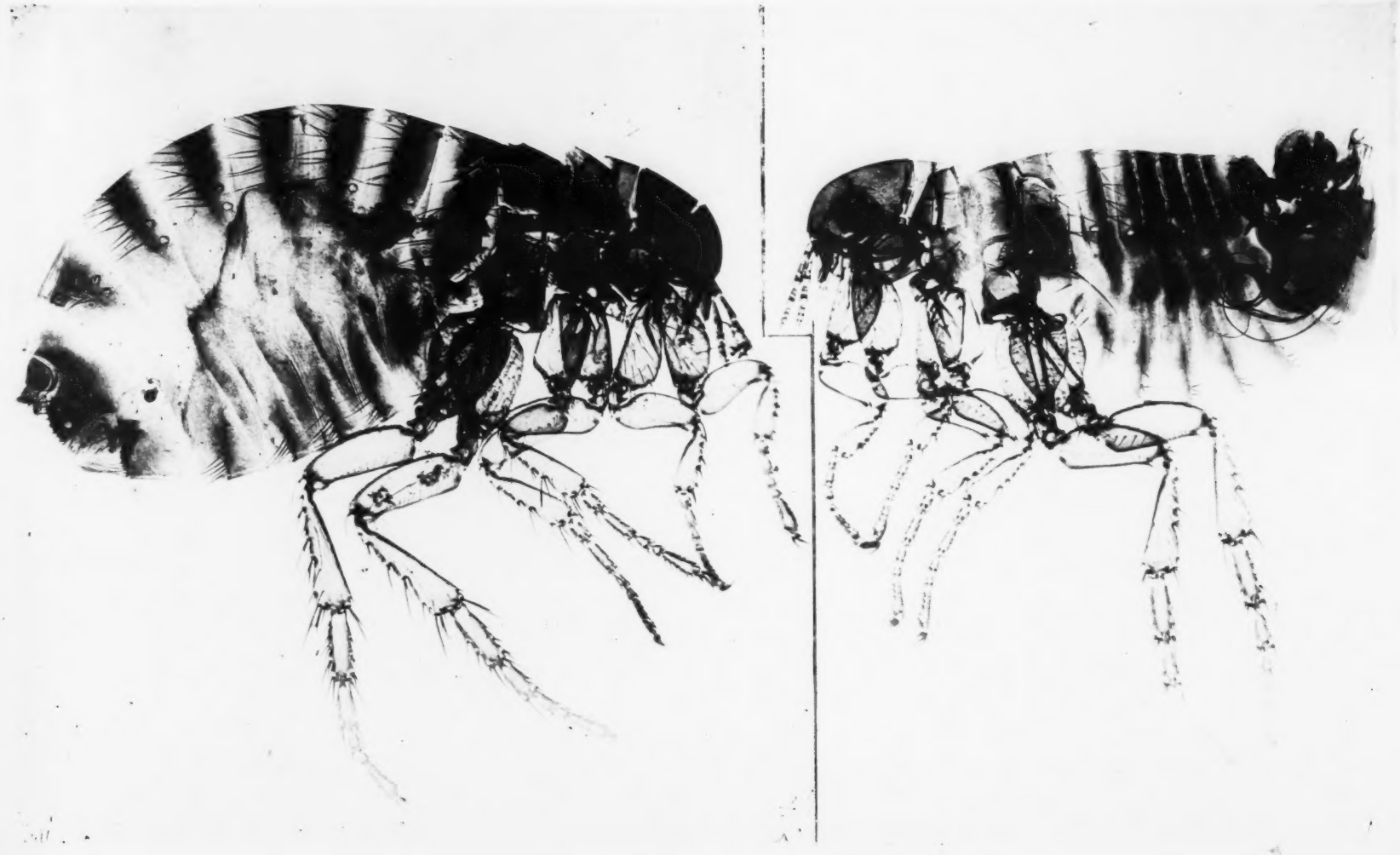
Female Flea (Enlarged about 40 Diameters).

Male Flea (Enlarged about 40 Diameters).



DOMESTIC PESTS: THE COMMON FLEA *(Pulex irritans).*

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